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Characterization of a midwestern fishery with limited exploitation

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Characterization of a midwestern fishery with limited exploitation

by

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ABSTRACT

Ada Hayden Heritage Park, Ames, Iowa, a mesotrophic quarry-pit fishery, was opened for new public exploitation on July 1, 2004 after many decades of private ownership and limited exploitation. A monthly, electro-fishing, population survey was conducted to both characterize the fishery and document any significant angler impacts from June 2003 to October 2004; an expandable creel survey was conducted from July 2004 to October 2004 to estimate angler use and analyze harvest change. The fishery is characterized by little to no structural habitat, high water quality, high diversity of 32 fish taxa including gizzard shad, low sport fish biomass, and an unbalanced bluegill population. Angler use peaked in July 2004 with 220 angler hrs/ha and fell rapidly to low levels. Creeled crappie, channel catfish, and yellow perch saw significant declines in average weight over time. Creel catch per unit effort (CPUE) did not significantly change as angling progressed for any species. Approximately 80% of the total fish biomass harvested since July 2004 was crappie species. Bluegill, channel catfish, yellow perch, freshwater drum, and green sunfish comprised the remaining 20%. Angler exploitation rate of bluegill ≥ 100 mm during the creel period was 13%. No significant changes in CPUE, proportional stock densities, and relative weights were detected after this fishery was opened to public fishing. However, largemouth bass stomach analyses indicated increased gizzard shad use after exploitation began. Due to the limited scope of the post-exploitation study period, future changes due to exploitation may be possible.

CHAPTER 1. GENERAL INTRODUCTION

Fisheries management history is filled with numerous accounts of what should have been done to slow the demise of a fishery due to human exploitation (Wilkins and Golden 1983; Hoffnagle and Timmons 1989; Rieman and Beamesderfer 1990; Hutchings and Myers 1994; Hannesson 1996; Robbins 1996). Ada Hayden Heritage Park, Ames, Iowa, is now undergoing public exploitation for the first time. Good management guidelines must be used to abate the potential decline due to overexploitation of the fisheries. The two main goals of this project are to: (1) quantify the effects of increased exploitation in the Ada Hayden Heritage Park fishery, and (2) provide future management guidelines based on reliable, scientific data, and reference for the Ada Hayden Heritage Park fishery.

Ada Hayden Heritage Park background

Ada Hayden Heritage Park (AHHP) is a complex fishery defined by both human dimension and fisheries factors. The city of Ames, Iowa, relies on the park, nearly within the city limits, as a reserve, high quality water source. During years of drought (1977, 1981, 1988) the city has utilized this roughly 50-ha dredge line quarry waterbody to increase water flow in the nearby Skunk River (T. Neumann, Director of Water and Pollution Control Department, Ames, Iowa, personal communication). Water pumped from this relatively clean water source into the river with strategically placed low head dams raises the water level in the city's four municipal well fields during drought periods, thereby decreasing the likelihood of mandatory water conservation measures.

In 2001 the city of Ames purchased the lakes and nearly 187 ha of the watershed to protect and conserve the mesotrophic waterbody for future use as a reserve water source for citizens and secondarily as a low-impact recreational area. Due to past private ownership, this area contained a fishery with relatively limited exploitation rates.

The two lakes of AHHP are an uncommon resource for Iowa in terms of water quality as well as fisheries management in general. Midwestern states are known for high rates of cultural eutrophication in their waterbodies when compared to elsewhere in the U.S. and the world (Downing and McCauley 1992; Arbuckle and Downing 2001). The water quality of AHHP ranks superior to the majority of Iowa lakes in terms of nitrogen and phosphorus concentrations, and water clarity (Arbuckle and Downing 2001; Downing and Kopaska 2002).

Unexploited fisheries

AHHP is also uncommon in fisheries management as an unexploited fishery. Few studies have looked at unexploited populations in or around the midwest (Reed and Rabeni 1989; Paukert and Willis 2001). Unexploited populations typically are characterized as having populations of older, larger fish (Goedde and Coble 1981). After exploitation begins, length and age frequency distributions shift toward smaller and younger fish. Paukert and Willis (2001) also noted that an unexploited yellow perch *Perca flavescens* population had faster growth rates than an exploited population. Higher exploitation levels on coral reef fish communities were also related to decreases in abundance and biomass of larger fish (Dulvy et al. 2004).

Fisheries managers commonly recommend to not harvest the larger predators due to imbalances it may cause (Gablehouse 1987). Thus, decreasing the number of larger predator fish of AHHP, e.g. largemouth bass *Micropterus salmoides*, due to new exploitation may upset the dynamics of this whole system.

Present knowledge of the Ada Hayden Heritage Park fishery

A previous fisheries survey by Iowa Department of Natural Resource personnel in 2002 described 18 taxa present (Table 1.10) (D. McWilliams, Iowa Department of Natural Resources, unpublished data). Largemouth bass was the major predator. Many other game fish were present including: bluegill *Lepomis macrochirus*, black crappie *Pomoxis nigromaculatus*, channel catfish *Ictalurus punctatus*, yellow perch, and white crappie *Pomoxis annularis*. Gizzard shad *Dorosoma cepedianum* were also noted to be relatively abundant; gizzard shad are problematic for many midwestern fisheries. It must be noted that age-0 fish are not represented in any of data in Table 1.10.

Table 1.10. Taxa sampled in Ada Hayden Heritage Park in fall 2002 by the Iowa Department of Natural Resources (IA DNR) (D. McWilliams, unpublished data). Taxa listed by order of significance. Boxed % represents lumped order of significance by taxa as reported by IA DNR. No age-0 fish are included.

<table>
<tr><th>#</th><th>Taxa</th><th>Scientific Name</th><th>% by number</th></tr>
<tr><td>1</td><td>Largemouth Bass</td><td>Micropterus salmoides</td><td>35</td></tr>
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<tr><td>18</td><td>Hybrid Sunfish</td><td></td></tr>
</table>

Species diversity limitations

The species diversity of this quarry presents a problem in its management toward a better fishery. Aquatic systems have a limited amount of biomass they can support. Additional species create increased competition and more energy stored in non-desirable fish species, thereby reducing the potential for a better sport fishery.

Gizzard shad, when present, frequently overpopulate and lock up biomass potential in aquatic systems (Jenkins 1957; Noble 1981). They are very prolific and mature at 1 to 2 years (Kilambi and Baglin 1969; Noble 1981). The average 4-year old female contains nearly 100,000 eggs (Kilambi and Baglin 1969). This early age of maturity and prolific fecundity can easily lead to overabundance and the decline of the remaining fisheries (Noble 1981; Drenner 1983).

Gizzard shad also can outgrow predators very quickly. Wright (1970) found that the size of shad preyed upon by largemouth bass increased with predator size until largemouth bass reached a standard length of 275 mm where shad size usage stabilized around 154 mm. Further, age-0 largemouth bass are usually outgrown by age-0 gizzard shad, making them less usable as a prey base (Garvey and Stein 1998); thereby a bad choice for managers as a forage base in most situations. Also, gizzard shad are prone to high winter mortality in the upper midwest as Iowa is the northern boundary of their native distribution (Megrey 1980). Gizzard shad population dynamics make successful management of a fishery even more difficult.

Gizzard shad are also a hindrance to a healthy bluegill population. Swingle and Swingle (1968) saw a reduction in bluegill recruitment in the presence of gizzard shad. The number and size of bluegill decreased in an Illinois reservoir after shad became abundant (Drenner 1983). Hill (1983) also found that bluegill standing stocks acceptable to anglers were greater in midwestern lakes without gizzard shad present. Bluegill proportional stock density (PSD) ratios declined after the introduction of gizzard shad into Lake Paho, Missouri (Neuswanger 1983). The PSD index, as defined by Anderson (1980), is a common approach to assess the population structure of fishery stocks using length-frequency data (Gablehouse 1984).

Interference competition with gizzard shad decreases bluegill stocks as both species occupy the same feeding niche as zooplanktivores (Garvey and Stein 1998). Gizzard shad have been classified as both phytoplanktivores and zooplanktivores (Drenner 1983) while bluegills have been noted to prey upon zooplankton, as well as insects (Baumann and Kitchell 1974). Drenner et al. (1982) calculated that gizzard shad populations could filter the equivalent volume of an entire lake for zooplankton in 56-130 hours. Therefore, a population of gizzard shad could effectively remove much of the zooplankton bluegill and many age-0 fish rely on.

Nutrient limitations

The clean, clear waters of AHHP are an aesthetic benefit and a benefit as a reserve water source for Ames. However, low fertility waters are not highly productive. Aquaculturists commonly fertilize ponds to increase production (Boyd 1981; Kurten et al. 1999; Rogge et al. 2003). In natural systems, age-0 largemouth bass biomass estimates were positively related to fertility levels of reservoirs (Greene and Maceina 2000). Also, Allen et al. (1998) related black crappie abundance to Florida natural lake fertility. The mesotrophic status of AHHP limits the amount of energy and biomass the whole system can carry.

Littoral zone limitations

Quarry pit lakes commonly have steep shelving banks, as does AHHP (Titmus 1983). This leaves little shallow littoral zone around the perimeter and decreases the total photosynthetic energy brought into an aquatic system (Duarte and Kalff 1986). Further, many fish species use this habitat as spawning (Ehlinger 1997; Suski and Phillipp 2004), rearing (Hall and Werner 1977), and feeding areas (Baumann and Kitchell 1974). The limited amount of littoral zone in AHHP limits reproduction of species, such as bluegill and largemouth bass, as well as decreasing the amount of fish biomass the waters are capable of producing.

Study objectives

The two lakes of Ada Hayden Heritage Park were opened for public fishing July 1, 2004. Our objectives were to (1) characterize the lightly exploited fishery, (2) document any changes to the fishery due to new exploitation, (3) estimate angler usage and impact using a creel survey, and (4) recommend management practices for the future fishery of Ada Hayden Heritage Park.

Thesis organization

This thesis is organized into five chapters which are: (1) general introduction, (2) status of the fishery before and after exploitation, (3) estimates of angler usage, (4) stomach sampling technique effectiveness, and (5) general conclusions. All chapters are formatted according to the American Fisheries Society. Literature cited follows each chapter.

Literature Cited

Allen, M.S., M.V. Hoyer, and D.E. Canfield, Jr. 1998. Factors related to black crappie occurrence, density, and growth in Florida lakes. North American Journal of Fisheries Management 18:864-871.

Anderson, R.O. 1980. Proportional stock density (PSD) and relative weight (W_r): interpretive indices for fish populations and communities. Practical fisheries management: more with less in the 1980's. *in* S. Gloss and B. Shupp editors. Proceedings of the 1st Annual Workshop of the New York Chapter American Fisheries Society. (Available from New York Cooperative Fishery Research Unit, Ithaca, New York.

Arbuckle, K.E. and J.A. Downing. 2001. The influence of watershed land use on lake N:P in a predominantly agricultural landscape. Limnology and Oceanography 46:970-975.

Baumann, P.C. and J.F. Kitchell. 1974. Diel patterns of distribution and feeding of bluegill (*Lepomis macrochirus*) in Lake Wingra, Wisconsin. Transactions of the American Fisheries Society 103:255-260.

Boyd, C.E. 1981. Comparison of five fertilization programs for fish ponds. Transactions of the American Fisheries Society 110:541-545.

Downing, J.A. and E. McCauley. 1992. The nitrogen: phosphorus relationship in lakes. Limnology and Oceanography 37:936-945.

Downing, J.A. and J. Kopaska. 2002. Ames quarry diagnostic study. Iowa State University Limnology Lab, Ames, Iowa.

Duarte, C.M. and J. Kalff. 1986. Littoral slope as a predictor of the maximum biomass of submerged macrophyte communities. Limnology and Oceanography 31:1072-1080.

Dulvy, N.K., N.V.C. Polunin, A.C. Mill, and N.A.J. Graham. 2004. Size structural change in lightly exploited coral reef fish communities: evidence for weak indirect effects. Canadian Journal of Fisheries and Aquatic Sciences 61:466-475.

Drenner, R.W., W.J. O'brien, and J.R. Mummert. 1982. Filter-feeding rates of gizzard shad. Transactions of the American Fisheries Society 111:210-215.

Drenner, R.W. 1983. Gizzard shad, lake food webs and fisheries management. Pages 19-29 *in* Proceedings of Small Lakes Management Workshop: "Pros and Cons of Shad". Iowa Conservation Commission and Sport Fishing Institute. Des Moines, Iowa.

Ehlinger, T.J. 1997. Male reproductive competition and sex-specific growth patterns in bluegill. North American Journal of Fisheries Management 17:508-515.

Gablehouse, Jr., D.W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Gablehouse, Jr., D.W. 1987. Responses of largemouth bass and bluegills to removal of surplus largemouth bass from a Kansas pond. North American Journal of Fisheries Management 7:81-90.

Garvey, J.E. and R.A. Stein. 1998. Linking bluegill and gizzard shad prey assemblages to growth of age-0 largemouth bass in reservoirs. Transactions of the American Fisheries Society 127:70-83.

Goedde, L.E. and D.W. Coble. 1981. Effects of angling on a previously fished and an unfished warmwater fish community in two Wisconsin lakes. Transactions of the American Fisheries Society 110:594-603.

Greene, J.C. and M.J. Maceina. 2000. Influence of trophic state on spotted bass and largemouth bass spawning time and age-0 population characteristics in Alabama reservoirs. North American Journal of Fisheries Management 20:100-108.

Hall, D.J. and E.E. Werner. 1977. Seasonal distribution and abundance of fishes in the littoral zone of a Michigan lake. Transactions of the American Fisheries Society 106:545-555.

Hannesson, R. 1996. Fisheries management: the case of the north Atlantic cod. Fishing News Books, Cambridge, Massachusetts.

Heidinger, R.C. 1983. Life history of gizzard shad and threadfin shad as it relates to the ecology of small lake fisheries. Pages 1-18 *in* Proceedings of small lakes management workshop: “pros and cons of shad”. Iowa Conservation Commission and Sport Fishing Institute. Des Moines, Iowa.

Hill, K.R. 1983. Comparison of fish standing stocks in small Iowa lakes with and without gizzard shad. Pages 44-57 *in* Proceedings of small lakes management workshop: “pros and cons of shad”. Iowa Conservation Commission and Sport Fishing Institute. Des Moines, Iowa.

Hoffnagle, T.L. and T.J. Timmons. 1989. Age, growth, and catch analysis of the commercially exploited paddlefish population in Kentucky Lake, Kentucky-Tennessee. North American Journal of Fisheries Management 9:316-326.

Hutchings, J.A. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, *Gadus morhua*, of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences 51:2126-2146.

Jenkins, R.M. 1957. The effect of gizzard shad on the fish population of a small Oklahoma lake. Transactions of the American Fisheries Society 85:58-74.

Kilambi, R.V. and R.E. Baglin, Jr. 1969. Fecundity of the gizzard shad, *Dorosoma cepedianum* (LeSueur), in Beaver and Bull Shoals reservoirs. American Midland Naturalist 82:444-449.

Kurten, G., L. Hall, and N. Thompson. 1999. Evaluation of cottonseed meal supplementation of inorganically fertilized Florida largemouth bass spawning ponds. North American Journal of Aquaculture 61:115-125.

Megrey, B.A. 1980. *Dorosoma cepedianum* (LeSueur), gizzard shad. P. 69 *in* D.S. Lee et al., editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina.

Neuswanger, D.J. 1983. Effects of gizzard shad introduction on the fishery of Lake Paho, Missouri. Pages 87-99 *in* Proceedings of small lakes management workshop: “pros and cons of shad”. Iowa Conservation Commission and Sport Fishing Institute. Des Moines, Iowa.

Noble, R.L. 1981. Management of forage fishes in impoundments of the southern United States. Transactions of the American Fisheries Society 110:738-750.

Paukert, C.P. and D.W. Willis. 2001. Comparison of exploited and unexploited yellow perch *Perca flavenscens* (Mitchill) populations in Nebraska sandhill lakes. Fisheries Management and Ecology 8:533-542.

Reed, M.S. and C.F. Rabeni. 1989. Characteristics of an unexploited smallmouth bass population in a Missouri Ozark stream. North American Journal of Fisheries Management 9:420-426.

Rieman, B.E. and R.C. Beamesderfer. 1990. White sturgeon in the lower Columbia River: is the stock overexploited? North American Journal of Fisheries Management 10:388-396.

Robbins, W.G. 1996. The world of Columbia River salmon: nature, culture, and the great river of the west. Pages 2-25 *in* J. Cone and S. Ridlington, editors. The northwest salmon crisis: a documentary history. Oregon State University Press, Corvallis, Oregon.

Rogge, M.L., A.A. Moore, and J.E. Morris. 2003. Organic and mixed organic-inorganic fertilization of plastic-lined ponds for fingerling walleye culture. North American Journal of Aquaculture 65:179-190.

Suski, C.D. and D.P. Philipp. 2004. Factors affecting the vulnerability to angling of nesting male largemouth and smallmouth bass. Transactions of the American Fisheries Society 133:1100-1106.

Swingle, H.S. and W.E. Swingle. 1968. Problems in dynamics of fish populations in reservoirs. Pages 229-243 *in* Reservoir fishery resources symposium. Southern Division, American Fisheries Society, Athens, Georgia.

Titmus, G. 1983. Biology of fisheries in gravel quarries. The Proceedings of a Symposium on the Subject of Wildlife of Man-made Wetlands 35: 109-120.

Wilkens, M.E. and J.T. Golden. 1983. Condition of the Pacific Ocean perch resource off Washington and Oregon during 1979: results of a cooperative trawl survey. North American Journal of Fisheries Management 3:103-122.

Wright, L.D. 1970. Forage size preference of the largemouth bass. The Progressive Fish Culturist 32:39-42.

CHAPTER 2. CHARACTERIZATION OF A MIDWESTERN FISHERY WITH LIMITED EXPLOITATION

A paper to be submitted to the North American Journal of Fisheries Management

Andy L. Fowler and Joseph E. Morris

Abstract

Ada Hayden Heritage Park, Iowa, is a new public gravel quarry fishery acquired by the city of Ames in 2001; it was opened as a public fishery July 2004. Monthly electro-fishing surveys were conducted from June 2003 to October 2004. The fishery is characterized by little to no structural habitat, high water quality, high diversity of 32 fish taxa including gizzard shad, low sport fish biomass, and an unbalanced bluegill population. No significant changes in proportional stock densities, catch per hour, relative weights, and food habits of largemouth bass were detected after exploitation began, except, largemouth bass preyed upon more gizzard shad and dipterans after exploitation. However, due to the short period of post-exploitation studied, additional changes after exploitation may be detected in the future.

Introduction

There are a small number of studies that have investigated the dynamics of populations before exploitation (Goedde and Coble 1981; Donald and Alger 1986; Kocovsky 1999; Paukert and Willis 2001), but there are few to no studies detailing unexploited or lightly exploited fisheries in the midwest (Goedde and Coble 1981;

Paukert and Willis 2001). Research is necessary to characterize unexploited or lightly exploited midwest fisheries for use in future management considerations.

Ada Hayden Heritage Park (AHHP) has been recently acquired by the city of Ames, Iowa, and was opened for public use on July 1, 2004. The two park water basins have had limited fisheries exploitation due to past private ownership of the land. Current city regulations include: catch and release only on black bass (*Micropterus* species), daily bag limits of 5 and 10 crappie (*Pomoxis* spp.) and bluegill (*Lepomis macrochirus*), respectively, no fishing in designated spawning grounds during spring, and no outboard motors allowed. All other regulations are pursuant to the standards established by the Iowa Department of Natural Resources.

Water quality of AHHP ranks superior to the majority of Iowa lakes in terms of nitrogen and phosphorus concentrations, and water clarity (Arbuckle and Downing 2001; Downing and Kopaska 2002). However, midwestern states are known for high rates of cultural eutrophication in their waterbodies when compared to elsewhere in the U.S. and the world (Downing and McCauley 1992; Arbuckle and Downing 2001). Cultural eutrophication results in low water clarity through sediment input, increased nutrients, and algal blooms (Wade and Heady 1976; Knowlton and Jones 1996; Whitcomb 2000). The low nutrient levels and high water clarity in AHHP may limit biomass production.

Biomass production has been closely linked to nutrient levels in lakes. Allen et al. (1998) noted, in a study of Florida lakes, a higher occurrence of black crappie *Pomoxis annularis* in fertile waters. Also, Budy et al. (1998) documented increased growth in kokanee salmon *Oncorhynchus nerka* through fertilized enclosure experiments in an oligotrophic lake. Further, common carp *Cyprinus carpio* growth increased with added nutrients in a study by Haines (1973).

Unexploited populations are unique and change in predictable ways after exploitation begins. Unexploited populations typically are characterized as having large populations of older, larger fish (Goedde and Coble 1981). Paukert and Willis (2001) also noted faster growth rates in an unexploited yellow perch *Perca flavescens* population compared to an exploited population. After exploitation began, Goedde and Coble (1981) noted that length and age frequency distributions shifted toward smaller sizes and younger ages. Further, fish abundance and biomass were negatively related to exploitation level by Dulvy et al. (2004). Fisheries managers commonly recommend not harvesting larger predators due to imbalances it may cause (Gablehouse 1987); decreases in number, size, and growth of larger predator fish, e.g. largemouth bass *Micropterus salmoides*, in AHHP due to new exploitation may upset the dynamics of the whole system.

Other changes have been noted during a fisheries' initial opening into new exploitation. The proportional stock density (PSD) index, as defined by Anderson (1980), is a common approach to assess the population structure of fishery stocks using length-frequency data (Gablehouse 1984a). The PSD uses standards for minimum stock and quality lengths for each species. Stock length is the size that fish often reach maturity while quality length is the size that most anglers prefer to catch.

Goedde and Coble (1981) saw PSD ranges in sport fish species fall from above recommended ranges to below recommended ranges on a newly exploited lake in Wisconsin over 6 years. We predict that sport fish PSD values in AHHP will decrease, and increase in prey species as exploitation commences.

A previous unpublished fisheries survey of the AHHP fishery by the Iowa Department of Natural Resource personnel (IA DNR) in 2002 described 18 fish taxa present (Table 2.10) (D. McWilliams, IA DNR). Largemouth bass was the major predator. Many other game fish were present including: bluegill, black crappie *Pomoxis annularis*, channel catfish *Ictalurus punctatus*, yellow perch, and white crappie *Pomoxis annularis*. Gizzard shad *Dorosoma cepedianum* were also noted to be relatively abundant; this species is often problematic for midwestern fisheries. All data in Table 2.10 does not include age-0 fish.

Table 2.10. Taxa sampled in Ada Hayden Heritage Park in fall 2002 by the Iowa Department of Natural Resources (IA DNR) (D. McWilliams, unpublished data). Taxa listed by order of significance. Boxed taxa represent lumped order of significance as reported by the IA DNR. No age-0 fish are included.

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Gizzard shad, when present, have been shown to be major contributors to predator-prey dynamics of largemouth bass (Garvey and Stein 1998; Michaletz 1998b; Allen et al. 1999). Gizzard shad is a very fecund species and usually mature in 1 to 2 years (Kilambi and Baglin 1969; Noble 1981). The average 4-year old female contains nearly 100,000 eggs (Kilambi and Baglin 1969).

Gizzard shad population dynamics and interactions with other species have been documented with mixed results. Age-0 gizzard shad have high growth rates and can outgrow the age-0 largemouth bass in the first year and all largemouth bass in 2-3 years (Noble 1981). This leads to gizzard shad overpopulation and a general decline of the overall fishery. Age-0 largemouth bass growth varied more in Ohio reservoirs dominated by gizzard shad than reservoirs dominated by bluegills (Garvey and Stein 1998). However, fall weights of age-0 largemouth bass in gizzard shad dominated reservoirs were equal to or higher than fall weights in bluegill dominated reservoirs.

Michaletz (1998a) noted the mere presence of gizzard shad was not as important as growth of gizzard shad. He found largemouth bass and white crappie grew faster in deep, less-productive reservoirs where slow growing age-0 gizzard shad were present. Overall, fishery professionals have mixed feelings on using gizzard shad as largemouth bass forage (Noble 1981).

Growth potential of gizzard shad may be limited. Drenner et al. (1984) noted gizzard shad significantly suppress available phytoplankton as a food source. Thus, chlorophyll *a* is a good measure of food abundance for gizzard shad, as chlorophyll *a* is found in all plants including phytoplankton. Allen et al. (1999) found a positive correlation between chlorophyll *a* concentrations and age-0 gizzard shad densities in a study of Alabama reservoirs; Michaletz (1999) positively related age-0 gizzard shad growth to Missouri reservoir chlorophyll *a* concentrations. However, Michaletz (1999) collected no larval shad in the oligo-mesotrophic reservoirs at that time. Mesotrophic AHHP has relatively low chlorophyll *a* values (Downing and Kopaska 2002); thus, growth potential of AHHP shad could be limited and consequently a dynamic part of this fishery.

Gizzard shad are a dynamic species in the upper midwest as Iowa is the northern boundary of the native distribution (Megrey 1980) where the species is prone to high winter mortality. This dynamic makes successful management even more difficult; therefore, many fisheries professionals disagree with stocking gizzard shad for this reason, as well as, their potentially harmful effects upon native sport fish populations (Noble 1981).

Gizzard shad are major competitors with bluegill; these fishes occupy the same feeding niche as planktivorous feeders (Cramer and Marzolf 1970; Baumann and Kitchell 1974). Hill (1983) saw consistently lower biomass estimates of bluegill in lakes with gizzard shad, opposed to lakes without gizzard shad. Relative weight is an index of the actual weight to the expected weight, at a given length of a species (Wege and Anderson 1978). Bluegill relative weight and growth increased after shad were removed from an Alabama lake (Moss and Reeves 1983). In addition, Drenner et al. (1982) calculated that gizzard shad populations could filter the equivalent volume of an entire lake for zooplankton in 56-130 hours, thereby, considerably removing a primary food resource for bluegills.

This study's goal is to document the fishery's condition and observe changes using assessments pre and post-exploitation. Future analysis is focused upon specific target species and species of interest, including: black crappie, white crappie, bluegill, gizzard shad, and largemouth bass. Channel catfish were originally considered a target species; however, low catch rates did not allow for good statistical comparisons. Consequently, channel catfish were dropped from future analysis.

Our objectives were to: (1) assess species diversity and calculate population estimates for comparison to other fisheries, (2) assess changes in catch per unit effort after exploitation begins, (3) use length frequency histograms and PSD values to assess changes in population structure after exploitation begins, (4) use relative weights to compare any possible changes in condition of target fish species after exploitation begins, (5) calculate average growth rates for comparison to other fisheries, and (6) analyze stomach contents of largemouth bass pre- and post-exploitation.

Methods

Site description

This study was conducted at Ada Hayden Heritage Park, Ames, Iowa. This former quarry site is characterized by dimictic cycling, mesotrophic nutrient enrichment, little littoral zone, and high water clarity as described by Downing and Kopaska (2002). The waterbody consists of a north and south basin (16 ha and 34 ha respectively). The lake form (relative hypsographic curve) is extremely concave from mining operations leaving steep, shelving banks; maximum depths reach 14.6 and 18.6 m in the north and south basin respectively. Summer temperatures reach 28-29° C with a mean of approximately 22° C at the surface during the summer. Hypoxic zones reach all but the top 7 and 5 m of the north and south basins, respectively, during some parts of the summer.

The north basin has a watershed of 96 ha, equivalent to a 6:1 watershed to lake area ratio while the south basin has a watershed of 1054 ha, equivalent to a 31:1 ratio. Major uses of the watershed reside in 59% cropland, 15% cool season grasses, and 10% residential. The remaining 16% is in various land cover types. Wetland structures were added in 2003 to intercept and reduce nutrient loading from major drainages into the waterbody.

Each basin was assigned three 20-min long initial electro-fishing stations. Each station was then assigned two seining sites, except for station #1 that had three seining sites. Stations and sites were assigned by considering the gear types' ability to catch the most representative sample of the fishery in a particular habitat due to the low amounts of littoral zone available. Electro-fishing sites and their coordinates are shown in Figure 2.10 and Table 2.11, respectively.

Both basins and fish populations were disconnected by a narrow isthmus preceding park restoration efforts that began in July 2003. However, the basins were connected on September 27, 2003, after a portion of this isthmus was removed and replaced by a bridge.

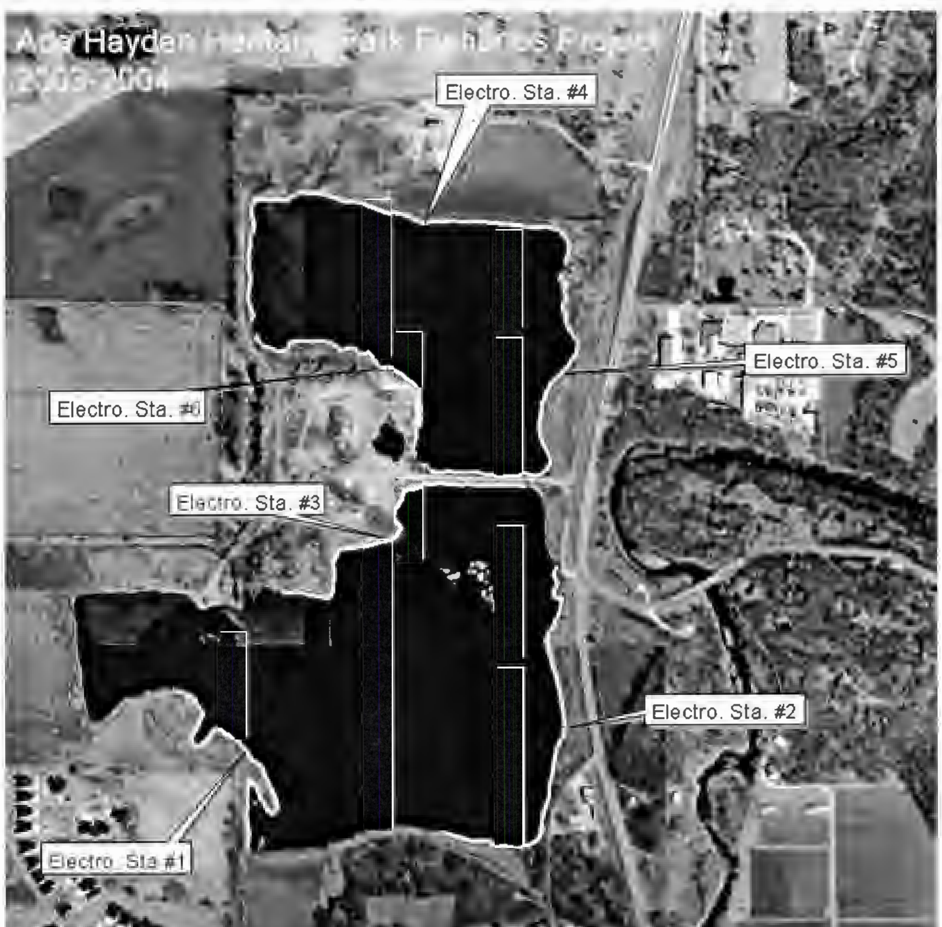


Figure 2.10. Electro-sampling station layout in Ada Hayden Heritage Park, Ames, Iowa, 2003-2004.

Table 2.11. Electro-sampling stations in Ada Hayden Heritage Park, Ames, Iowa, 2003-2004, universal transverse mercator (UTM) coordinates, 15T North American datum (NAD) (1983). Data was collected with a Garmin 12XL Personal Navigator GPS unit, 15 m accuracy, using autonomous data collection with no correction or averaging.

Station	Easting (m)	Northing (m)
Start: Station 1 Electro-sampling	0447750	4657160
Stop: Station 1 Electro-sampling	0447870	4656900
Start: Station 2 Electro-sampling	0448210	4656920
Stop: Station 2 Electro-sampling	0448410	4657370
Start: Station 3 Electro-sampling	0448350	4657510
Stop: Station 3 Electro-sampling	0447930	4657330
Start: Station 4 Electro-sampling	0447870	4657790
Stop: Station 4 Electro-sampling	0448420	4657880
Start: Station 5 Electro-sampling	0448420	4657880
Stop: Station 5 Electro-sampling	0448170	4657560
Start: Station 6 Electro-sampling	0448170	4657560
Stop: Station 6 Electro-sampling	0447890	4657760

Methodology

A quadrant bag seine was used at each seining station in 2003 with allowances made for the steep slopes of the study site by use of a boat. However, bag seining was discontinued in April 2004 due to new installed rip-rap; bank stabilization structure was used in all stations. The seine was unable to be effectively pulled over such structures. Consequently, seining is not included in any further discussion.

A boat electro-fisher (Coffelt Electro-fisher, Model 20-CPS, Smith Root, Inc. Vancouver, WA) was used once per month (one basin per night for a total of 2 nights per month) on each basin during the open water season for each station. The sampling began June 2003 and ended October 2004. Sampling occurred near or on the new moon phase to avoid possible biases in sampling gizzard shad because gizzard shad exhibit negative phototaxis (Michaletz 1997). Volts, amps, conductivity, dissolved oxygen, and water temperature were recorded when gear was available for collection. The duration monitor on the electro-fisher unit was recorded in seconds for each station during each sampling month. Fish species collected were identified down to species and family according to Pflieger (1997).

In 2003, the electro-fishing procedure consisted of processing 50 randomly selected gizzard shad for total length per station. The first 30 individuals were weighed to the nearest 0.1 g using an electronic scale (Scout Pro, Model SP4001, Ohaus Corporation, Pine Brook, New Jersey).

All largemouth bass were measured for total length. The first 30 randomly chosen individuals per station were weighed to the nearest 0.1 g. The right opercle was tagged with a small, metal, numerical tag (National Band and Tag Company, Style 893, Size 1 and 3, Newport, Kentucky). Scale samples were removed from 10 fish above the lateral line and below the dorsal fin (Devries and Frie 1996).

Stomach contents of 10 largemouth bass per station were sampled by a modified gastric lavage technique as discussed in Light et al. (1983) using a 12-volt, 600-gph water pump (Simer Blue Water Pump, Model No. BW85P, Delavan, Wisconsin) and flexible tubing (10 mm, outside diameter, 6 mm, inside diameter). Due to possible gear and biological constraints, the minimum length sampled for stomachs was 200 mm. All lake water used to flush stomachs was pre-filtered using

500-um mesh to prevent contamination of forage samples. Largemouth bass were not anesthetized as Fowler (2005b) noted zero mortality using no anesthesia in 1-week post-gastric lavage sampled largemouth bass. All stomach content samples were filtered through a 500-um mesh collection bottle to reduce water in the sample. Stomach contents samples were then stored in 10% buffered formalin solution. Fish were allowed to recover and then released.

All remaining species collected were identified and enumerated by station. The first randomly chosen 10 individuals of each remaining sport fish species also had length and weight taken as described earlier. The remaining target fish species include black crappie, white crappie, and bluegill. Further species were counted. No aging structures were taken on either groups of species during 2003.

The electrofishing procedure in 2004 was similar to that used in 2003. Ten individuals of all target species were sampled for scales above the lateral line and below the dorsal fin during each station of each sampling month (Devries and Frie 1996). A mark-recapture program to calculate population estimates was targeted on black crappie, white crappie, bluegill, and largemouth bass. Because tag retention on the opercle was low in 2003, according to unpublished data collected in October 2003, additional tagging methods were implemented in 2004. A Floy ® T-bar tag (Model No.'s FF-94 and FD-68B, Floy Tag Incorporated, Seattle, WA) was inserted just behind the dorsal fin. In 2004, the metal, opercular tag was also repositioned more tightly to the opercle compared to 2003 procedures and this significantly increased tag retention in unpublished data collected in April 2004. The left pectoral fin was also clipped.

A small number of gizzard shad and largemouth bass were sacrificed for later validation between otolith and scale aging techniques during 2003 and 2004. Specimens were preserved in 10% buffered formalin and individually marked (length, weight, date of collection, and site of collection). Otoliths were removed immediately to avoid deterioration in formalin and placed in vials of glycerin for later validation to scale aging techniques.

Data analysis

The Schnabel (1938) multiple-census formula was used to estimate the populations in each basin as described in Van den Avyle and Hayward (1999). Confidence intervals were calculated using a poisson random distribution due to low number of recaptures (Ricker 1975). Biomass estimates were calculated using the population estimates correlated to length-frequency distributions and associated average weights based on only unexploited sampling dates; this included all data from June 2003 to June 2004. Estimates were only calculated for bluegill and largemouth bass populations; population estimates were unable to be calculated for other species with no recaptures. Simpson's index of diversity was calculated for basin comparisons as $[\in n(n-1)] / [N(N-1)]$.

Electro-fishing catch per unit effort (CPUE) was adjusted to catch per hour fished. The proportional stock density index (PSD) was also calculated, as defined by Anderson (1980). It is a common assessment of fishery stocks using length-frequency data (Gablehouse 1984a). The PSD uses standards for minimum stock and quality lengths for each species. Stock length is the size that fish generally reach maturity while quality length is the size that most anglers prefer to catch. The PSD (%) is equivalent to (# fish $\geq$ quality length) / (# fish $\geq$ stock length).

The relative weight index (Wr) was calculated, as discussed in Wege and Anderson (1978). It is the ratio of actual weight of a fish to standard weight of that species at a given length. Standard weight equations were determined by references cited within Anderson and Neumann (1996).

Age was determined by scale samples prepared between glass slides and magnified using a "3M Consultant 114 Microfiche Reader, Model No. 297-BG, Saint Paul, Minnesota". Measurements from the focus to annuli and the scale edge were taken directly off the screen and validated by three readers. Scale annuli measurements from accepted scales were only used from one reader for later analysis throughout the study to keep proportions equal.

Stomach contents were analyzed by prey type: numerically, gravimetrically (wet weight) to the nearest 0.1 g using an electronic scale, and volumetrically to the nearest 0.1 ml using displacement in graduated cylinders.

Statistical analysis

Fish populations of both basins were treated separately due to their recent connection to each other and were considered the experimental units in this observational study, even though basin comparisons yielded few significant differences. Differences were analyzed by comparable seasons. Comparable seasons refer to summer and fall, 2003 and 2004. The summer season includes the months of July and August while the fall season includes September and October. Subsequent analysis will focus on target sport fish populations (black crappie, white crappie, bluegill, and largemouth bass) and species of interest (gizzard shad). We attempted to analyze channel catfish populations; however, the gear bias proved too much for categorical averaging to basin and season.

Seasonal values were analyzed using SAS 8.2 (SAS Institute, Cary, North Carolina) to determine significant differences in diversity indices, CPUE rates, PSD values, relative weights, and stomach sample analysis with the basin as the experimental unit. Significant differences between basins and seasons were analyzed using a generalized linear model incorporating the fixed effects of basin, (e.g., north), and season date, (e.g., fall 2004). Means per sampling month were calculated, assuming equal variance between categorical estimates. Individual comparison between basins and seasons were analyzed using the lsmeans procedure with a tukey adjustment (SAS Institute, Cary, North Carolina). All p values greater than or equal to 0.1 were considered significant.

Results

Species diversity and richness

Total species richness for both basins included 30 species, with two additional hybrids (hybrid striped bass *Morone chrysops x morone saxatilis* and hybrid bluegill *Lepomis macrochirus x* unknown), encompassing eight families (Table 2.12). The north basin contained 29 taxa while the south basin only contained 25 taxa. Simpson's diversity index value was 0.8 for both basins; diversity index values were not significantly different (P = 0.8263) between the north and south basin (Figure 2.11).

The largest percentage by number caught of species include: bluegill (30%), gizzard shad (20%), and largemouth bass (19%). Many less abundant species are lotic, species common to flowing water. After public use began on July 1, 2004, a member of the Pike family (Esocidae) was glimpsed during sampling on August 16, 2004 but was never netted and was not included in the analysis. Including the esocid would change the species diversity to 31 species and nine families. Also, a 442-mm hybrid striped bass was sampled on August 17, 2004.

Table 2.12. Species richness and percent composition based on total number of species caught at Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. Tr. = < 0.1%. Simpson's index of diversity = 0.8. Species sorted by family according to Nelson (1994) and decreasing abundance.

#	Family	Common Name	Scientific Name	Count	Species %	Family %
1	Clupeidae	Gizzard shad	*Dorosoma cepedianum*	2191	25.9	25.9
2	Cyprinidae	Bluntnose minnow	*Pimephales notatus*	90	1.1	
3	Cyprinidae	Common carp	*Cyprinus carpio*	74	0.9	
4	Cyprinidae	Fathead minnow	*Pimephales promelas*	57	0.7	
5	Cyprinidae	Common shiner	*Luxilus cornutus*	24	0.3	
6	Cyprinidae	Golden shiner	*Notemigonus crysoleucas*	9	0.1	3.1
7	Cyprinidae	Emerald shiner	*Notropis atherinoides*	6	Tr	
8	Cyprinidae	Bigmouth shiner	*Notropis dorsalis*	1	Tr	
9	Cyprinidae	Spotfin shiner	*Cyprinella spiloptera*	1	Tr	
10	Catostomidae	Quillback carpsucker	*Carpiodes cyprinus*	98	1.2	
11	Catostomidae	River carpsucker	*Carpiodes carpio*	73	0.9	
12	Catostomidae	Highfin carpsucker	*Carpiodes velifer*	50	0.6	
13	Catostomidae	Smallmouth buffalo	*Ictiobus bubalus*	35	0.4	3.2
14	Catostomidae	Bigmouth buffalo	*Ictiobus cyprinellus*	11	0.1	
15	Catostomidae	White sucker	*Catostomus commersoni*	3	Tr	
16	Catostomidae	Shorthead redhorse	*Moxostoma macrolepidotum*	1	Tr	
17	Ictaluridae	Channel catfish	*Ictalurus punctatus*	28	0.3	
18	Ictaluridae	Black bullhead	*Ameiurus melas*	1	Tr	Tr
19	Ictaluridae	Yellow bullhead	*Ameiurus natalis*	1	Tr	
20	Moronidae	Hybrid striped bass	*Morone chrysops x morone saxatilis*	1	Tr	Tr
21	Centrarchidae	Bluegill	*Lepomis macrochirus*	2550	30.2	
22	Centrarchidae	Largemouth bass	*Micropterus salmoides*	1600	18.9	
23	Centrarchidae	White crappie	*Pomoxis annularis*	646	7.7	
24	Centrarchidae	Green sunfish	*Lepomis cyanellus*	433	5.1	
25	Centrarchidae	Black crappie	*Pomoxis nigromaculatus*	112	1.3	63.5
26	Centrarchidae	Redear sunfish	*Lepomis microlophus*	10	0.1	
27	Centrarchidae	Hybrid bluegill	*Lepomis macrochirus x*	9	0.1	
28	Centrarchidae	Smallmouth bass	*Micropterus punctulatus*	4	Tr	
29	Percidae	Yellow perch	*Perca flavescens*	305	3.6	
30	Percidae	Fantail darter	*Etheostoma flabellare*	2	Tr	3.6
31	Percidae	Johnny darter	*Etheostoma nigrum*	1	Tr	
32	Sciaenidae	Freshwater drum	*Aplodinotus grunniens*	21	0.3	Tr

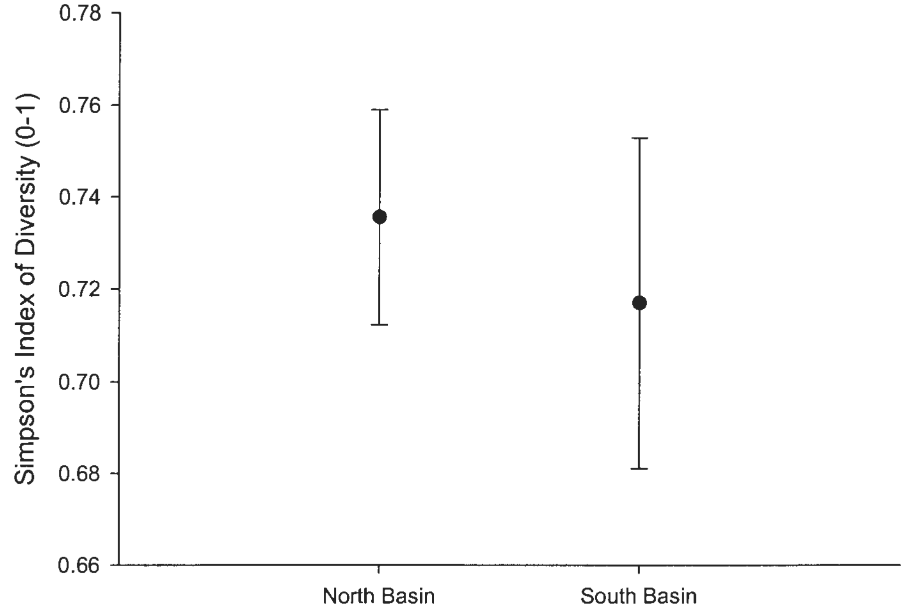


Figure 2.11. Simpson's index of diversity value in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004.

Population and biomass estimates

Population estimates were attempted on black crappie, bluegill, largemouth bass, and white crappie ≥ 100 mm. No recaptures were obtained on the *Pomoxis* species and population estimates were not calculated. Population estimates for bluegills and largemouth bass in both basins and pooled across basins are shown in Table 2.13. We marked 466 bluegill and 454 largemouth bass, receiving 11 and 39 recaptures respectively. Due to the low number of recaptures, population estimates incorporated recaptures from both the unexploited and exploited sampling dates. We acknowledge this violates the standard assumptions of a mark-recapture population estimate. However, it remained our only option with low recapture numbers. Due to calculations involved between number of marked and recaptured fish, north and south basins will not inherently sum up to the total population calculated in both basins.

Table 2.13. Population estimates and poisson 95% confidence intervals for selected species of both basins of Ada Hayden Heritage Park, Ames, Iowa, 2004.

Basin	Species	Population Estimate	Lower 95% C.I.	Upper 95% C.I.
North	Bluegill	3200	1600	7600
South	Bluegill	6400	2200	32200
Both	Bluegill	8100	4600	16500
North	Largemouth Bass	1000	600	1800
South	Largemouth Bass	1200	800	1900
Both	Largemouth Bass	2200	1600	3100

Bluegill ≥ 100 mm were estimated to have a biomass of 300 kg in the entire park (95% C.I. 200-700 kg) which is equivalent to 7 kg/ha (95% C.I. 4-14 kg/ha). Largemouth bass ≥100 mm were estimated to have a biomass of 400 kg in the entire park (95% C.I. 300-500 kg) which is equivalent to 8 kg/ha (95% C.I. 6-11 kg/ha).

Catch per unit effort (CPUE) (catch/hour)

Overall, basin ($p = .006$), season ($p = 0.028$), species ($p < 0.001$), and the basin*species interaction ($p = 0.002$) explains 76% of the CPUE variation with a 71.4% coefficient of variation. This model relates some important considerations. On average the south basin CPUE is 50 fish/hour higher than the north basin ($p = 0.006$) (Figure 2.12). Summer 2003 had on average, 60 fish/hour more than summer 2004 ($p = 0.044$) (Figure 2.13). White crappie CPUE was not significantly more than black crappie CPUE ($p = 0.812$) despite more abundance reported in Table 2.12. Comparing means from the basin*species interaction indicates that on average the gizzard shad CPUE for the south basin is 210 fish/hour higher than the north basin ($p = 0.002$). No other species' CPUE are significantly different across basins.

CPUE was quite variable across dates and basins by species. The north basin had a significantly higher black crappie CPUE ($p = 0.034$) (Figure 2.14). There was no significant difference between summer seasons of black crappie CPUE ($p_{Summer} = 0.999$), but fall 2004 did show a significant increase ($p_{Fall} = 0.076$). There was also no significant difference between basins ($p = 0.369$) and seasons ($p = 0.488$) of white crappie (Figure 2.15) or basins ($p = 0.562$) and seasons ($p = 0.424$) of bluegill (Figure 2.16) CPUE. During the 2003-summer, many age-0 white crappie were caught (Figure 2.15). Gizzard shad (Figure 2.17) had a significantly higher mean CPUE in the south basin by approximately 210 fish/hour ($p = 0.035$). Age-0 gizzard shad represent much of the catch in the south basin and therefore were separated for analysis. There was no significant difference in CPUE of all ($p = 0.673$) or age-0 ($p = 0.319$) (Figure 3.18) gizzard shad between seasons. Age-0 gizzard shad CPUE was significantly higher, 100 fish/hour, in the south basin compared to the north basin ($p = 0.028$) (Figure 3.18). Largemouth bass (Figure 2.19) CPUE was not significantly different by basins ($p = 0.130$). CPUE was significantly lower in largemouth bass by approximately 70 fish/hour in summer 2004 compared to summer 2003 ($p = 0.083$).

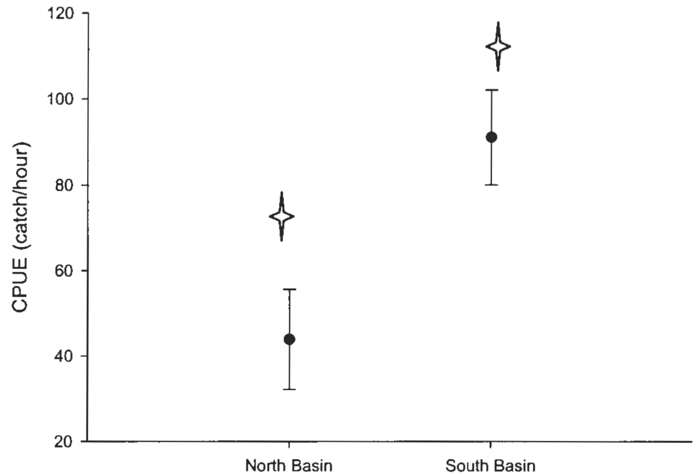


Figure 2.12. Overall catch per unit effort basin differences encompassing all target species at Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. Star represents a 0.1 significant difference.

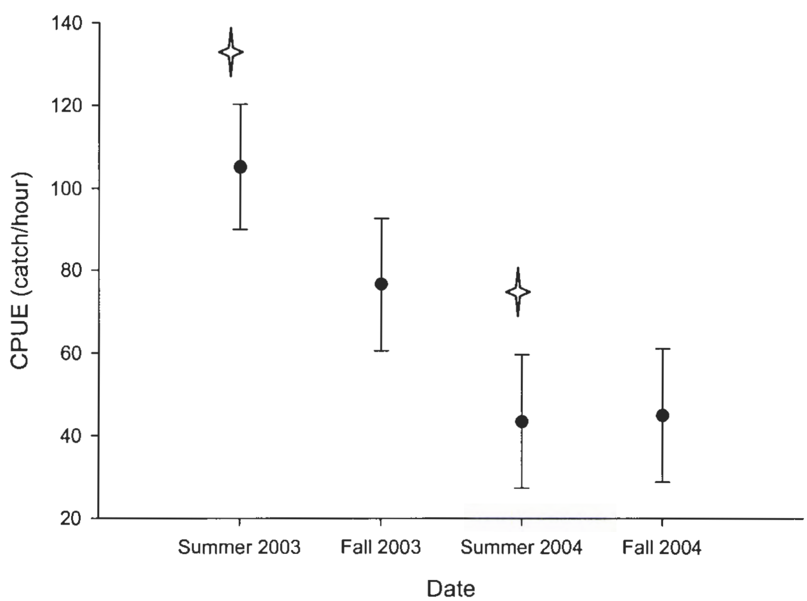


Figure 2.13. Overall catch per unit effort season differences encompassing all target species at Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. Star represents a 0.1 significant difference.

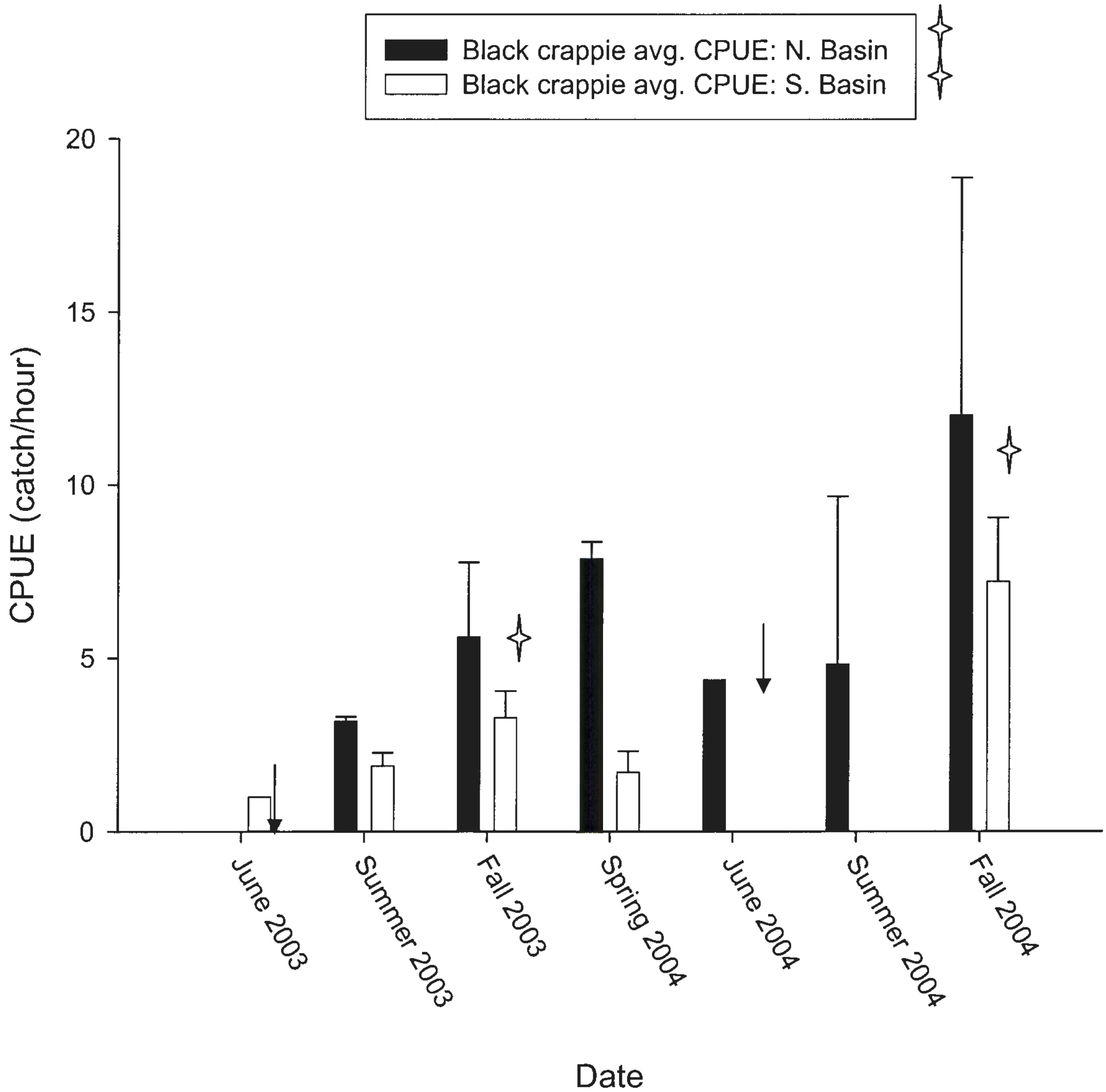


Figure 2.14. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of black crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Star represents a 0.1 significant difference.

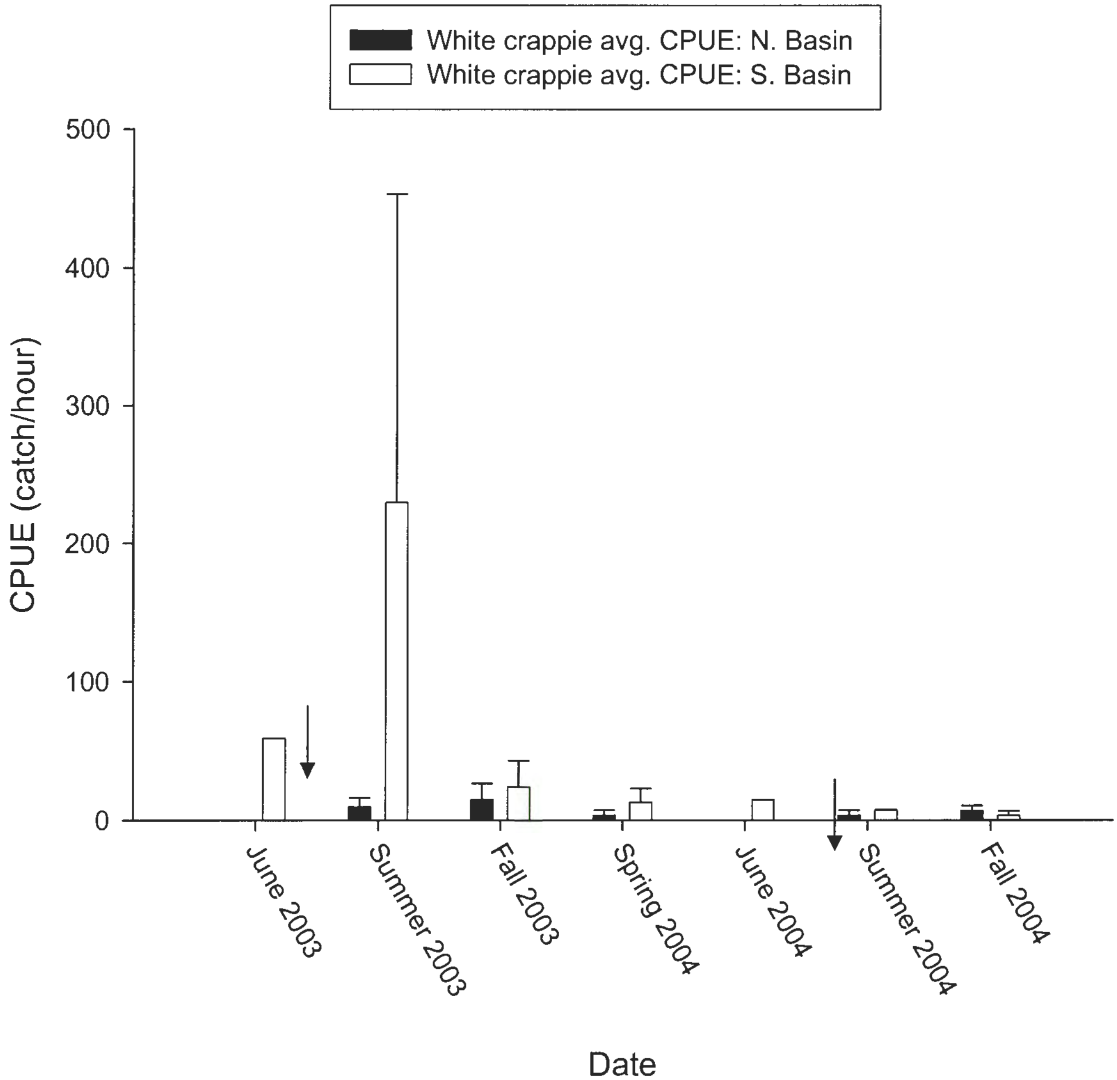


Figure 2.15. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of white crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation.

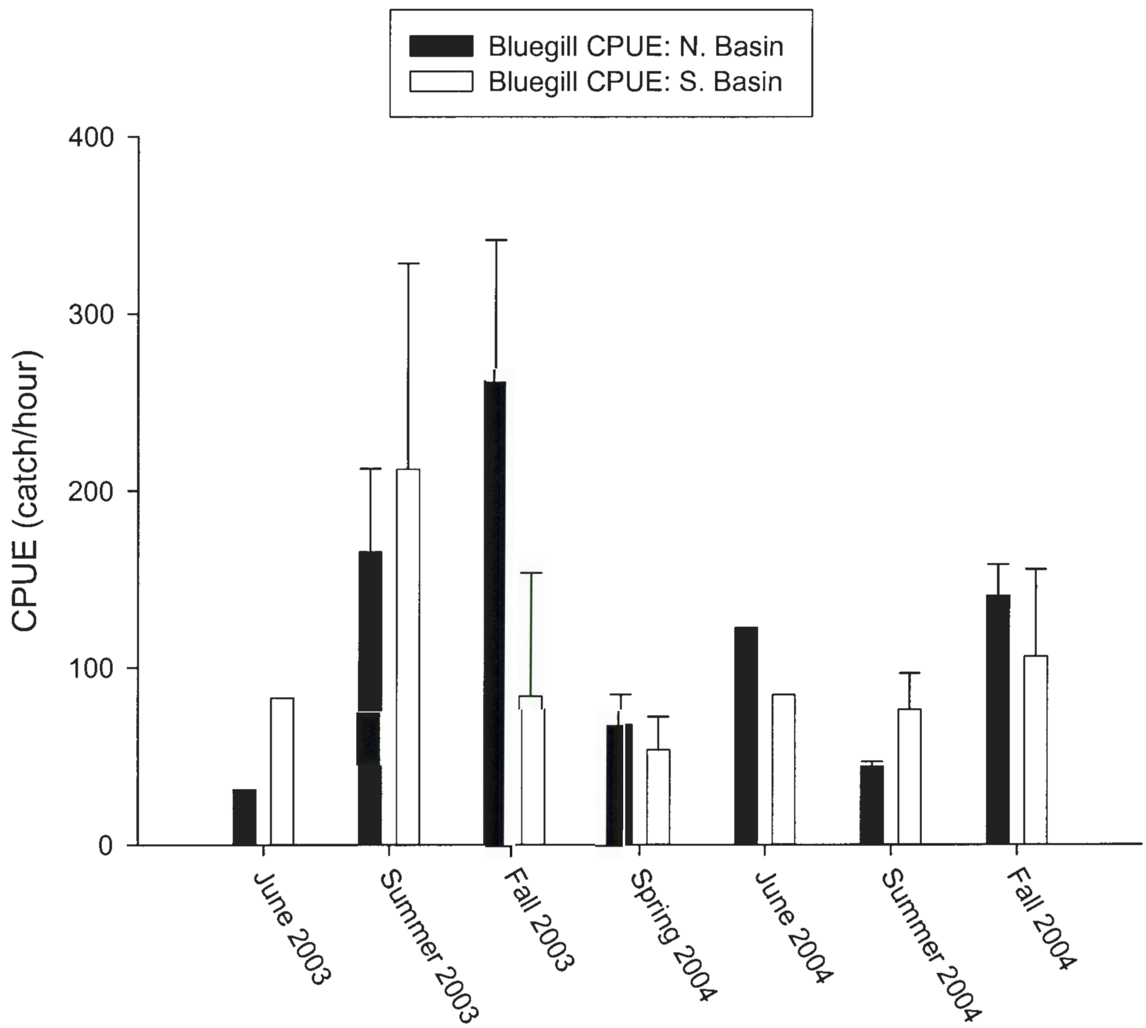


Figure 2.16. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of bluegill in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation.

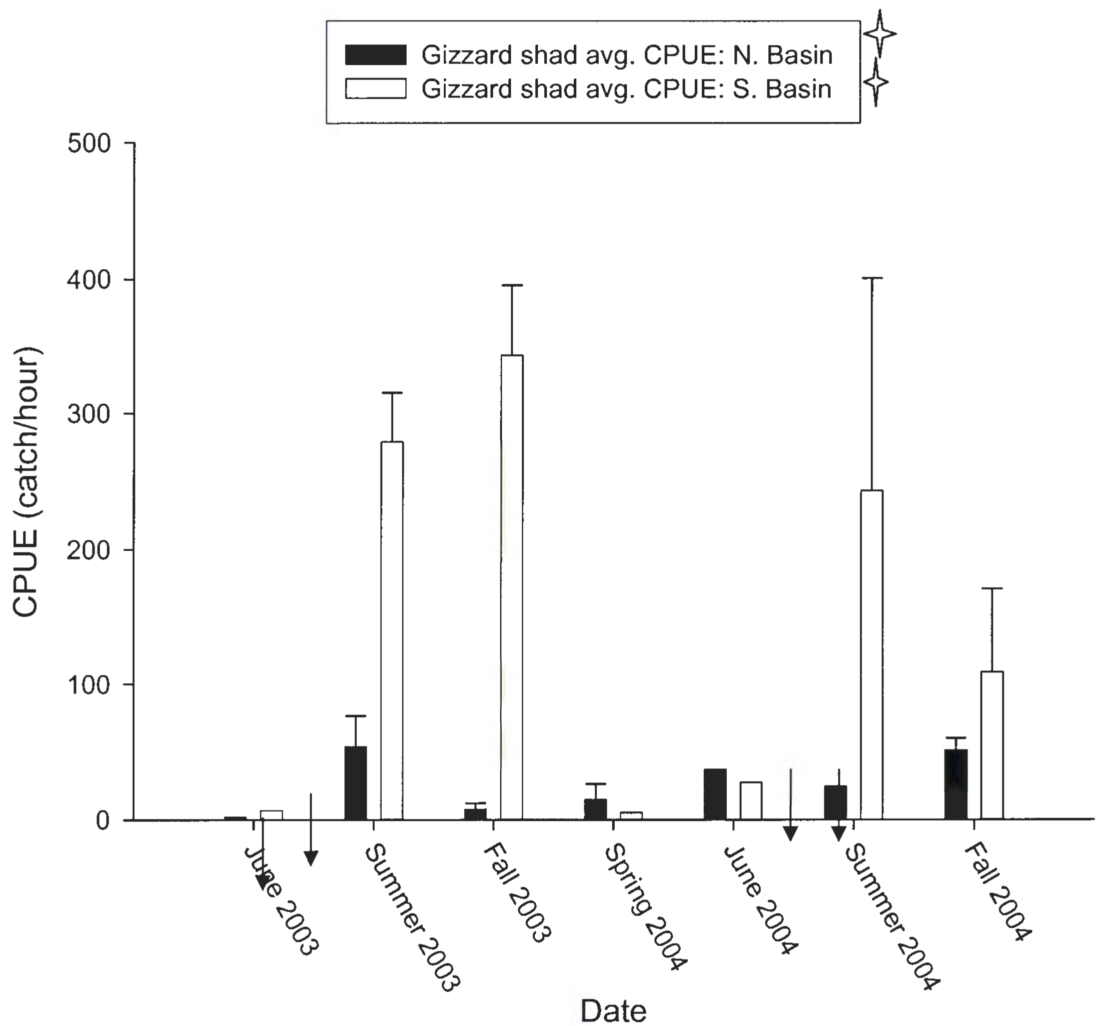


Figure 2.17. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of gizzard shad in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Star represents a 0.1 significant difference.

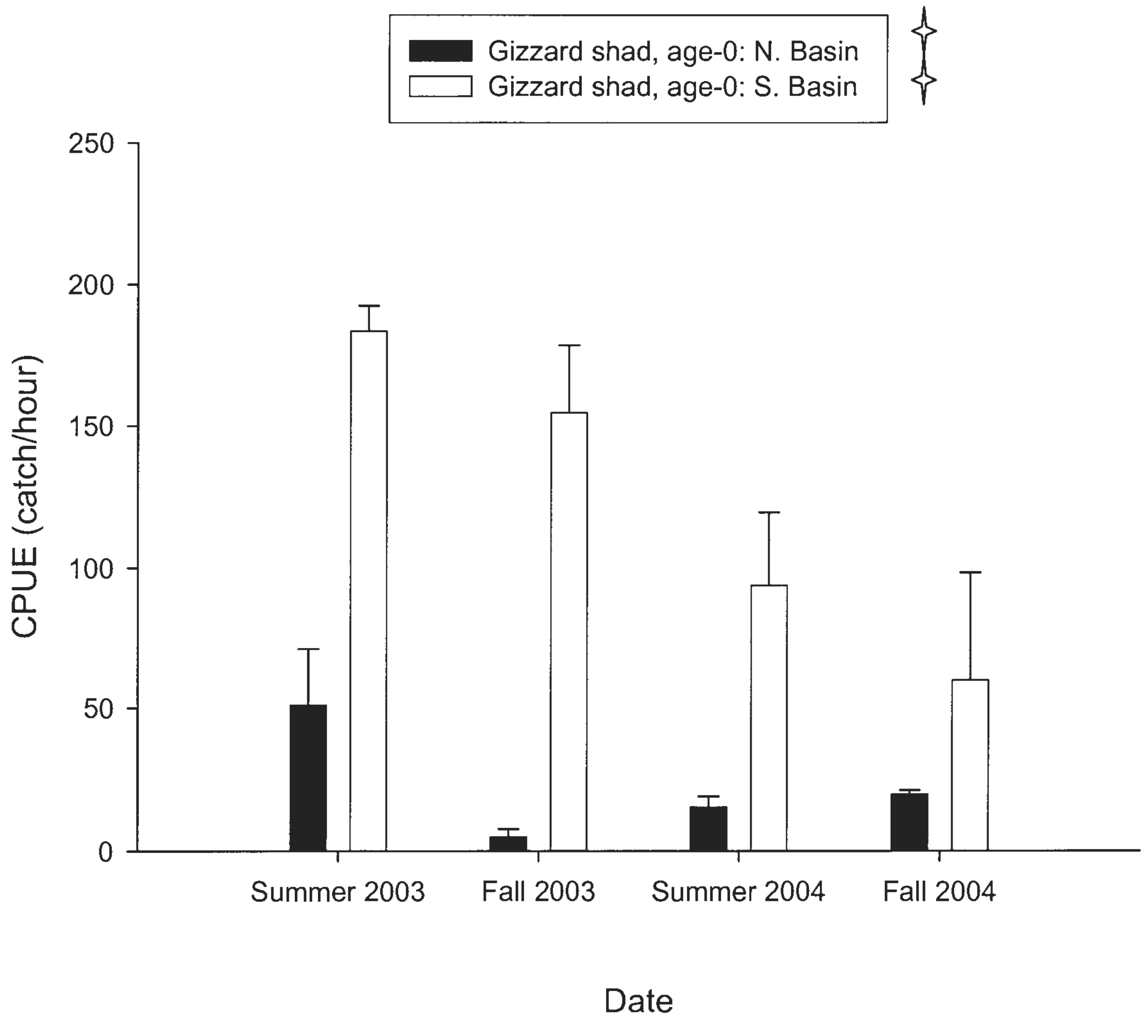


Figure 2.18. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of age-0 gizzard shad in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Star represents a 0.1 significant difference.

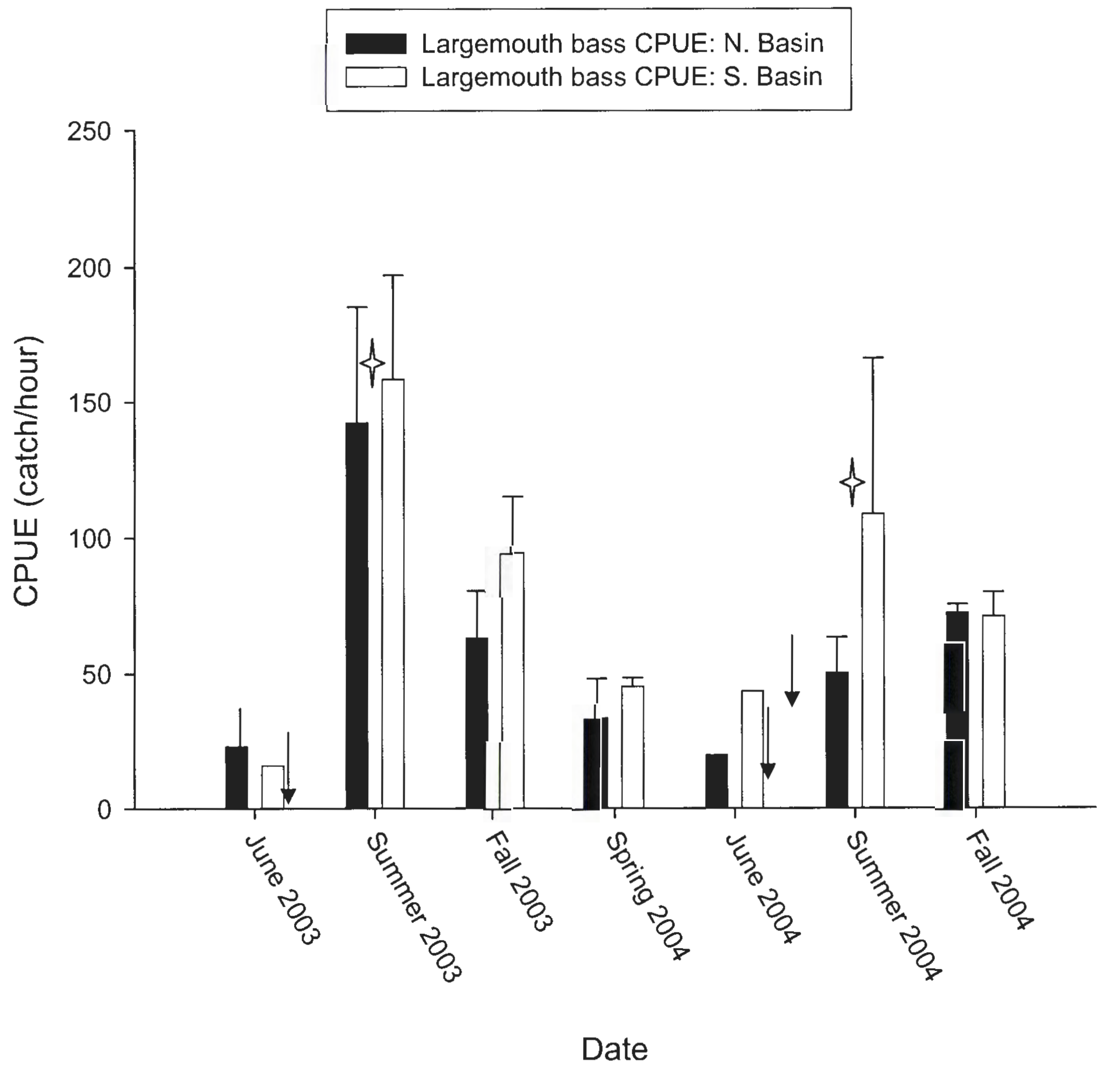


Figure 2.19. Mean electro-fishing catch per unit effort (CPUE) (catch/hour) (±SE) of largemouth bass in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Star represents a 0.1 significant difference.

Length-frequency histograms

Visual analysis of black crappie length frequencies (Figure 2.20) show low capture numbers of shorter, younger fish. There was a higher capture of shorter, younger white crappie (Figure 2.21) in 2003, as compared 2004. Bluegill (Figure 2.22) length frequencies represent a normal distribution; however, an increase in length of young fish is noticeable from 2003 to 2004. Gizzard shad (Figure 2.23) distributions of length frequencies are concentrated in the age-0 fish with few larger fish sampled. High catch rates of age-0 fish are also noticeable in largemouth bass (Figure 2.24) length frequency distributions; however, captures of larger, older fish dropped dramatically.

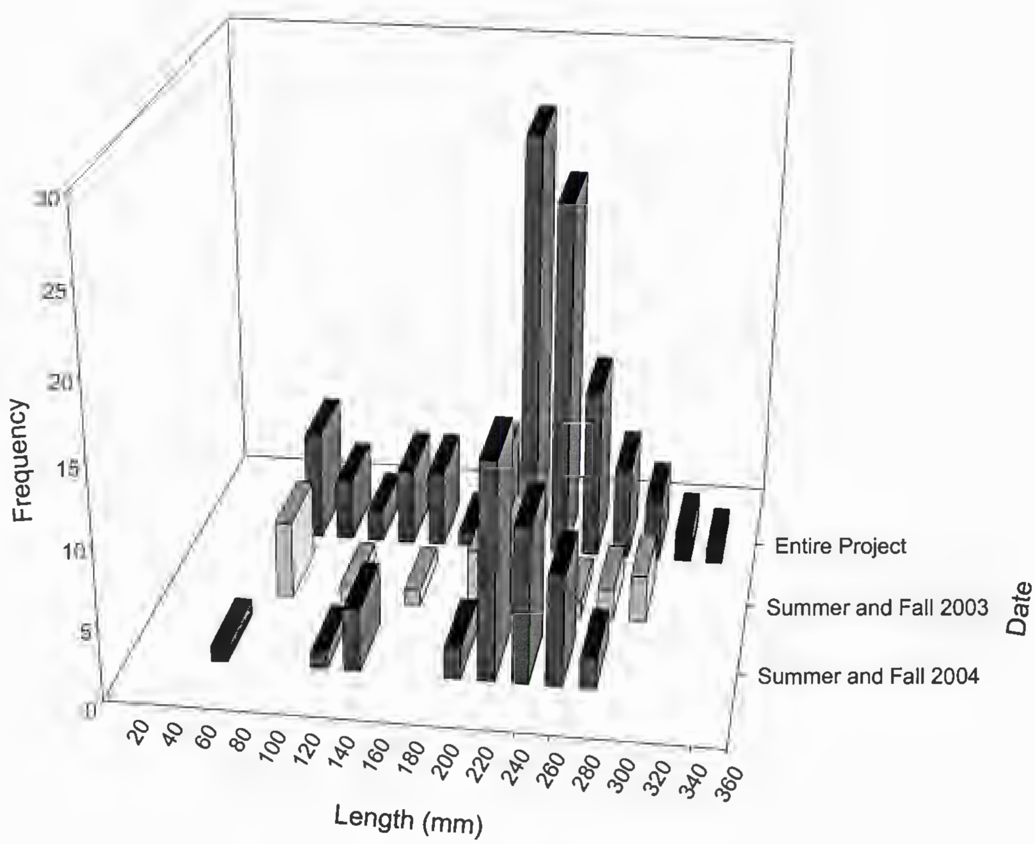


Figure 2.20. Length frequency histograms of electro-fished black crappie in both basins of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began Summer-2004.

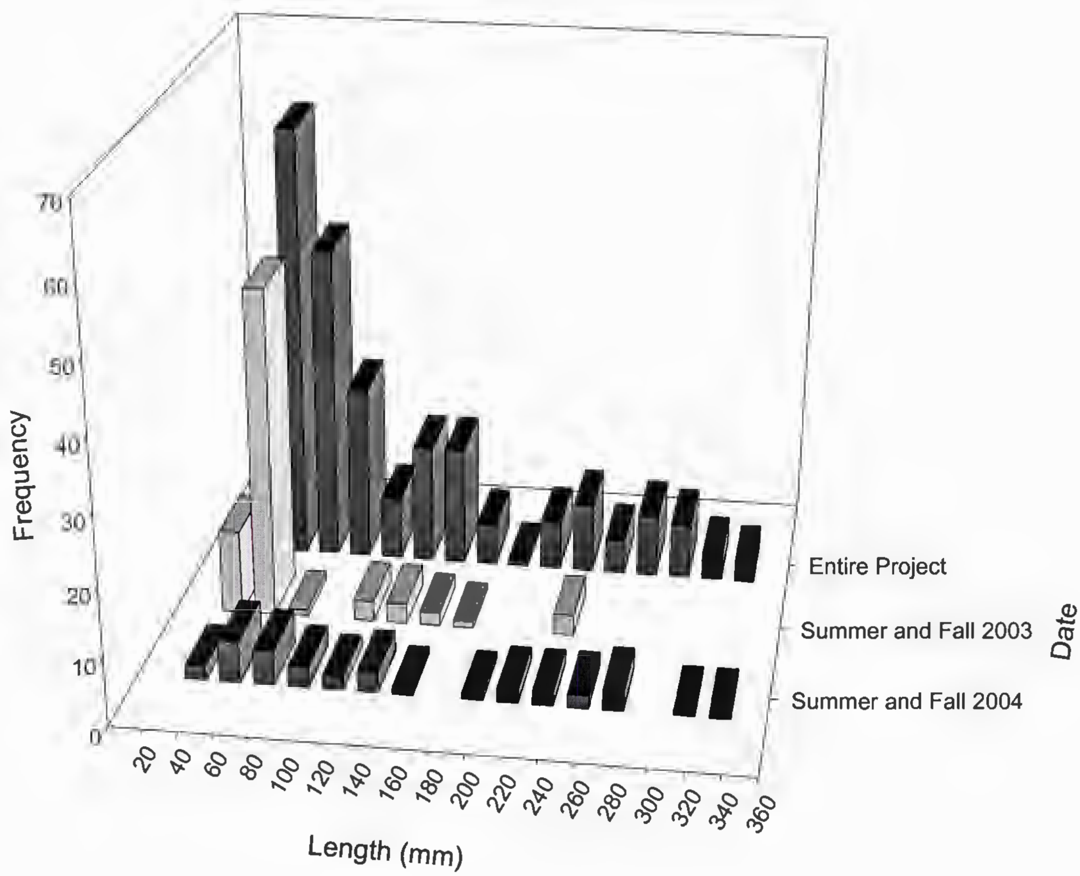


Figure 2.21. Length frequency histograms of electro-fished white crappie in both basins of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began Summer-2004.

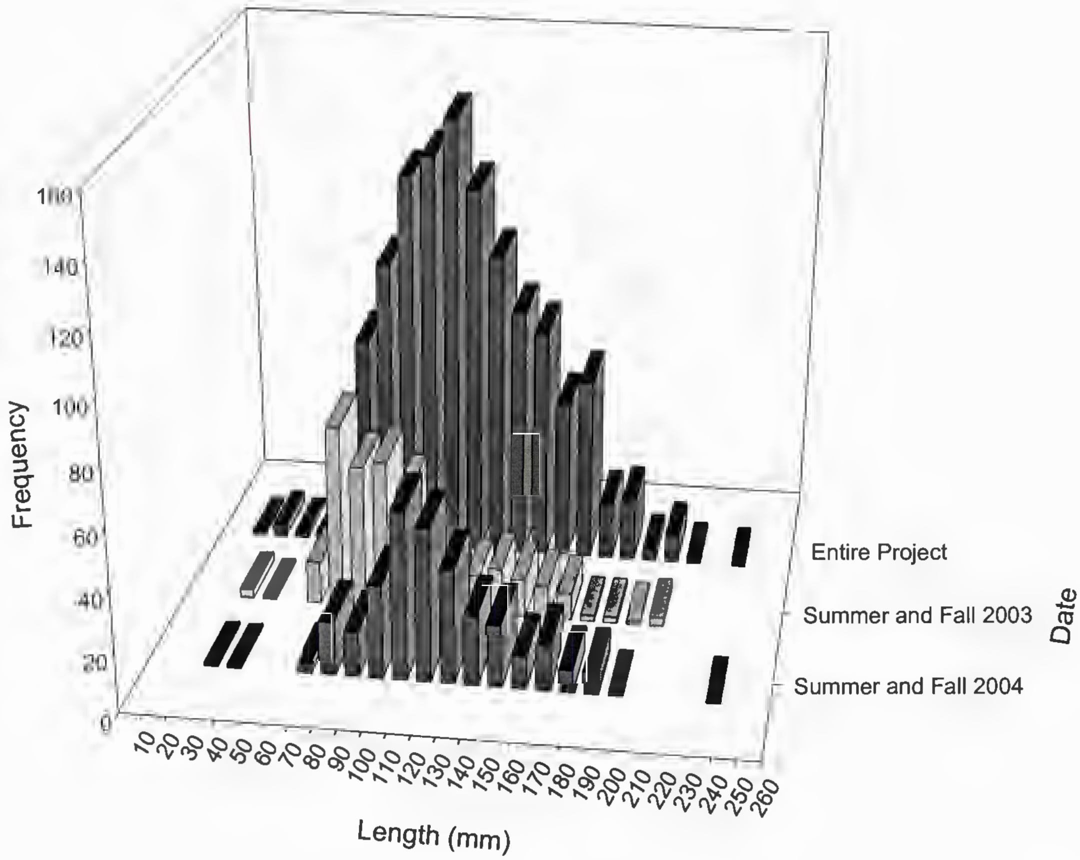


Figure 2.22. Length frequency histograms of electro-fished bluegill in both basins of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began Summer-2004.

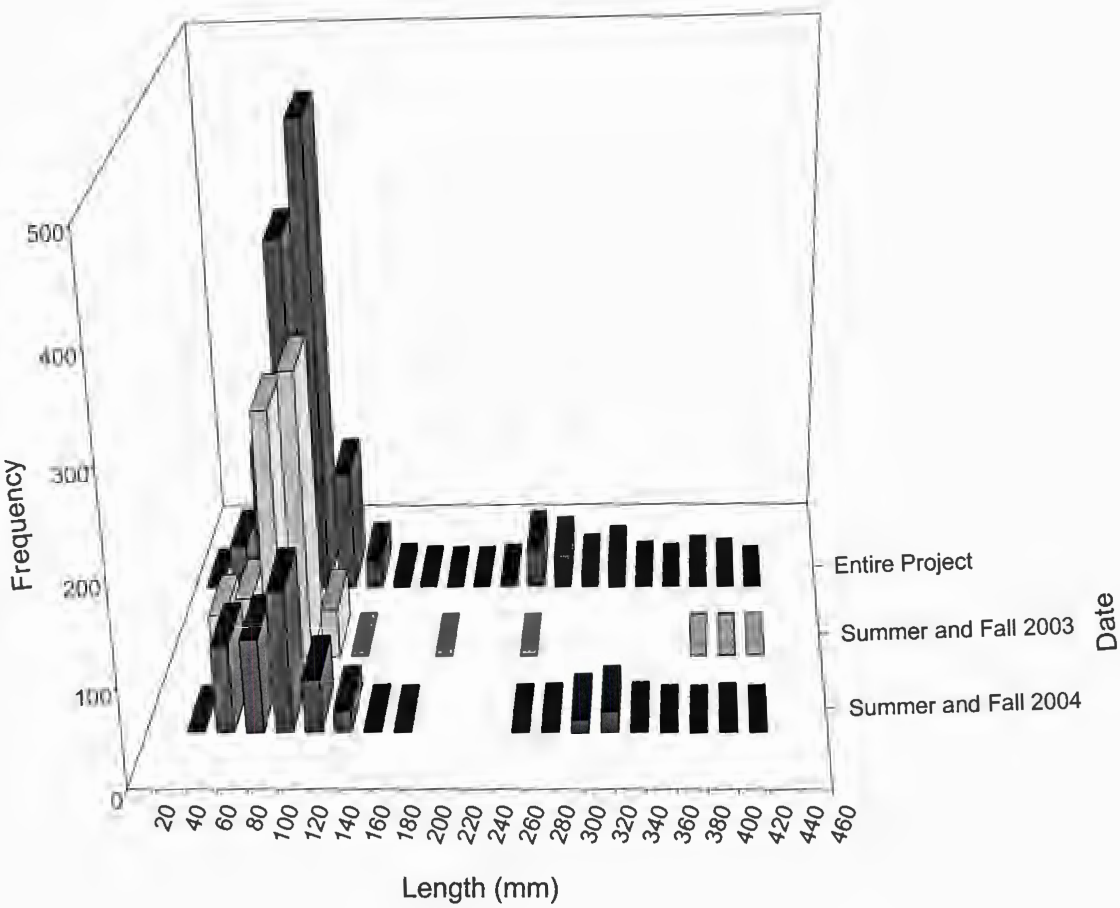


Figure 2.23. Length frequency histograms of electro-fished gizzard shad in both basins of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began Summer-2004.

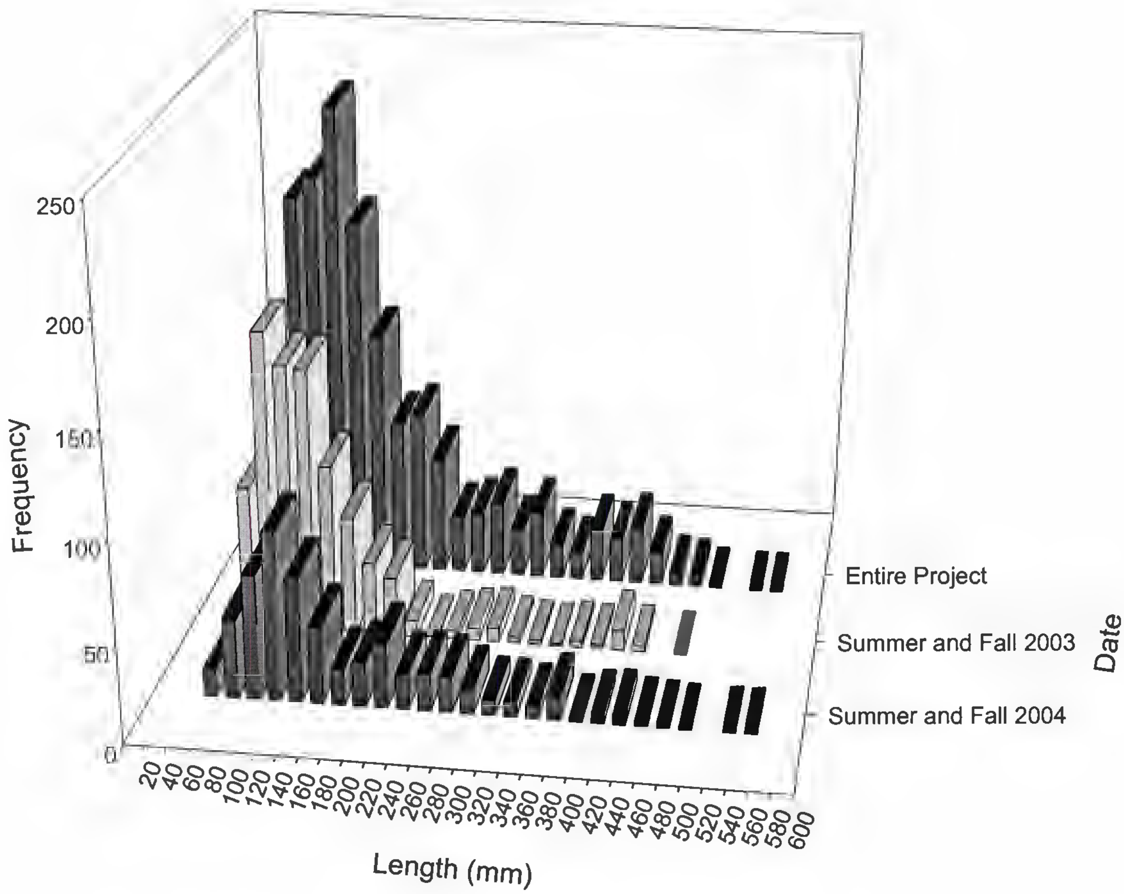


Figure 2.24. Length frequency histograms of electro-fished largemouth bass in both basins of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began Summer-2004.

Proportional stock densities (PSD)

The PSD's of all species were variable across dates, basins, and species. Black crappie PSD values (Figure 2.25) were not significantly different between basins ($p = 0.191$) or the fall seasons ($p_{Fall} = 0.311$); summer 2004 was significantly higher than summer 2003 by approximately 50 PSD index units ($p_{Summer} = 0.045$). PSD values were not significantly different in white crappie (Figure 2.26) between basins ($p = 0.341$) and seasons ($p = 0.636$) or bluegill (Figure 2.27) basins ($p = 0.184$) and seasons ($p = 0.468$). Gizzard shad PSD values (Figure 2.28) were not significantly different between basins ($p = 0.215$) and seasons ($p = 0.244$). The PSD values of largemouth bass (Figure 2.29) were not significantly different across basins ($p = 0.323$) or seasons ($p = 0.249$) as well. AHHP mean PSD index values are shown in Table 2.14.

Table 2.14. Mean proportional stock density (PSD) values in Ada Hayden Heritage Park, Ames, Iowa, 2003-2004.

Species	Mean PSD Index	±1 SE
Black crappie	80.09	7.55
White crappie	56.18	9.70
Bluegill	17.29	2.98
Gizzard shad	55.65	10.11
Largemouth bass	47.15	5.58

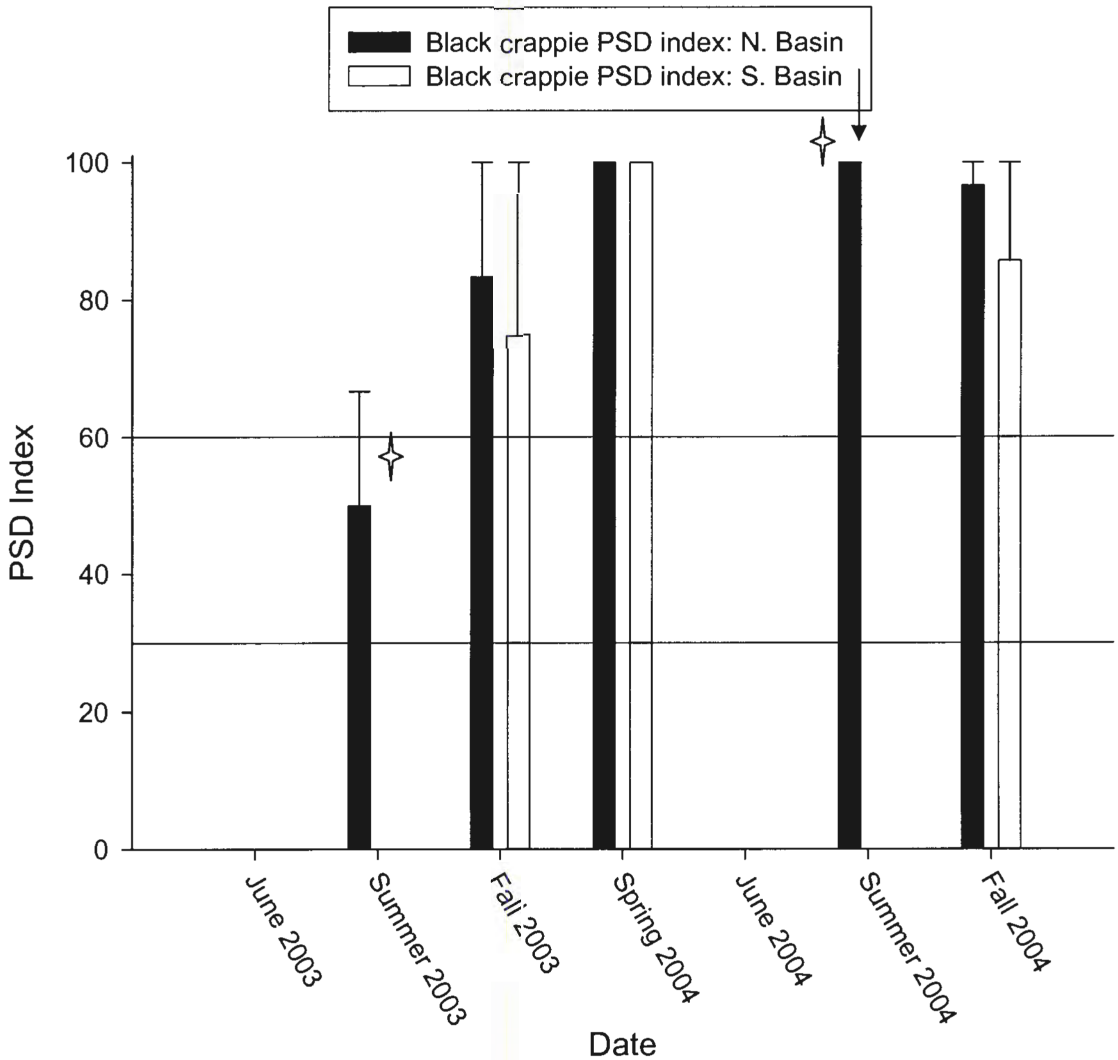


Figure 2.25. Mean proportional stock density (PSD) index (±SE) of electro-fished black crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Reference lines (30-60) indicate desired index ranges (Gablehouse 1984b). Arrow indicates only one monthly mean observation. Stock length (130 mm) and quality length (200 mm) referenced from Anderson (1980). Star represents a 0.1 significant difference.

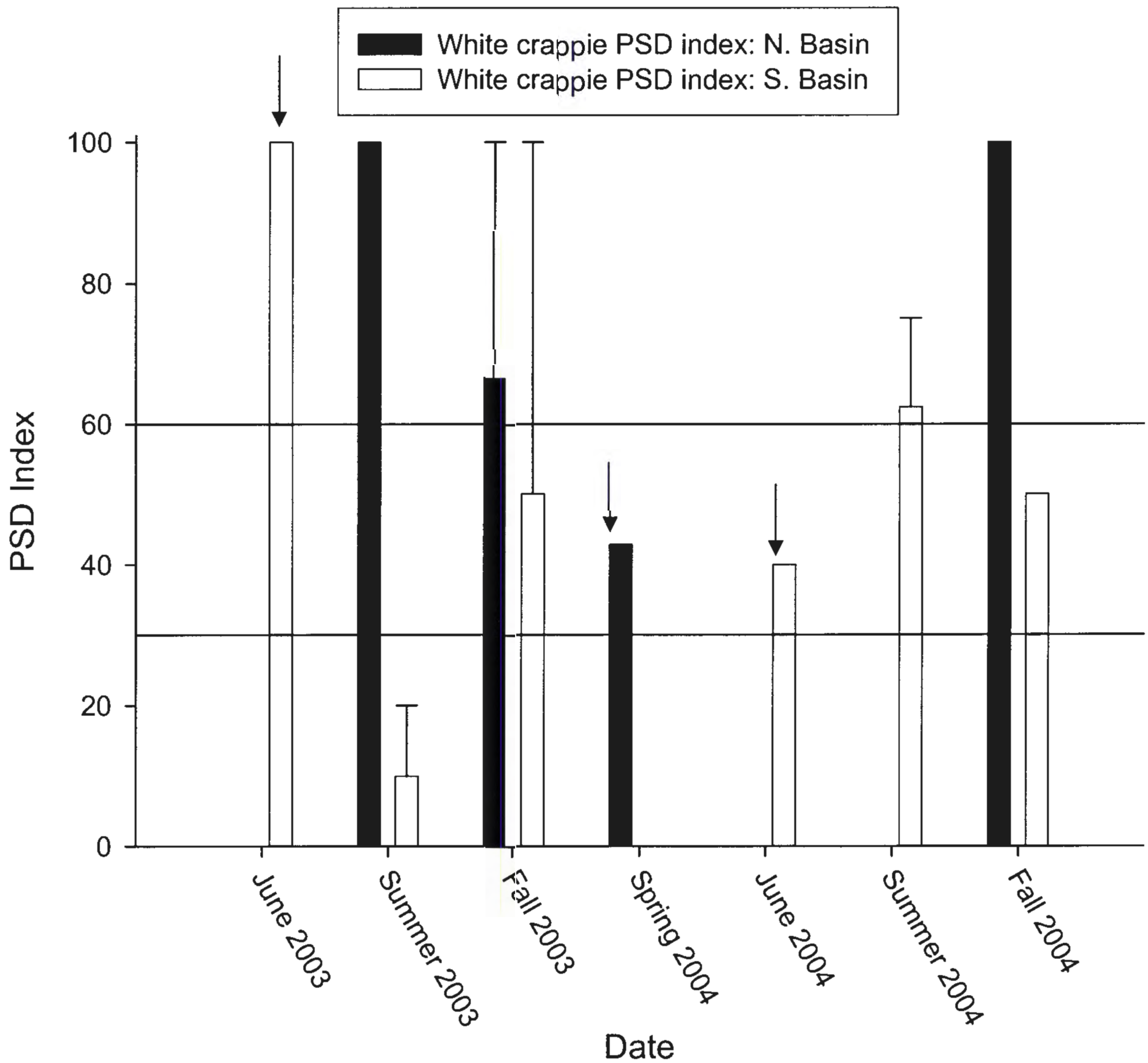


Figure 2.26. Mean proportional stock density (PSD) index (±SE) of electro-fished white crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Reference lines (30-60) indicate desired index ranges (Gablehouse 1984b). Arrow indicates only one monthly mean observation. Stock length (130 mm) and quality length (200 mm) referenced from Anderson (1980).

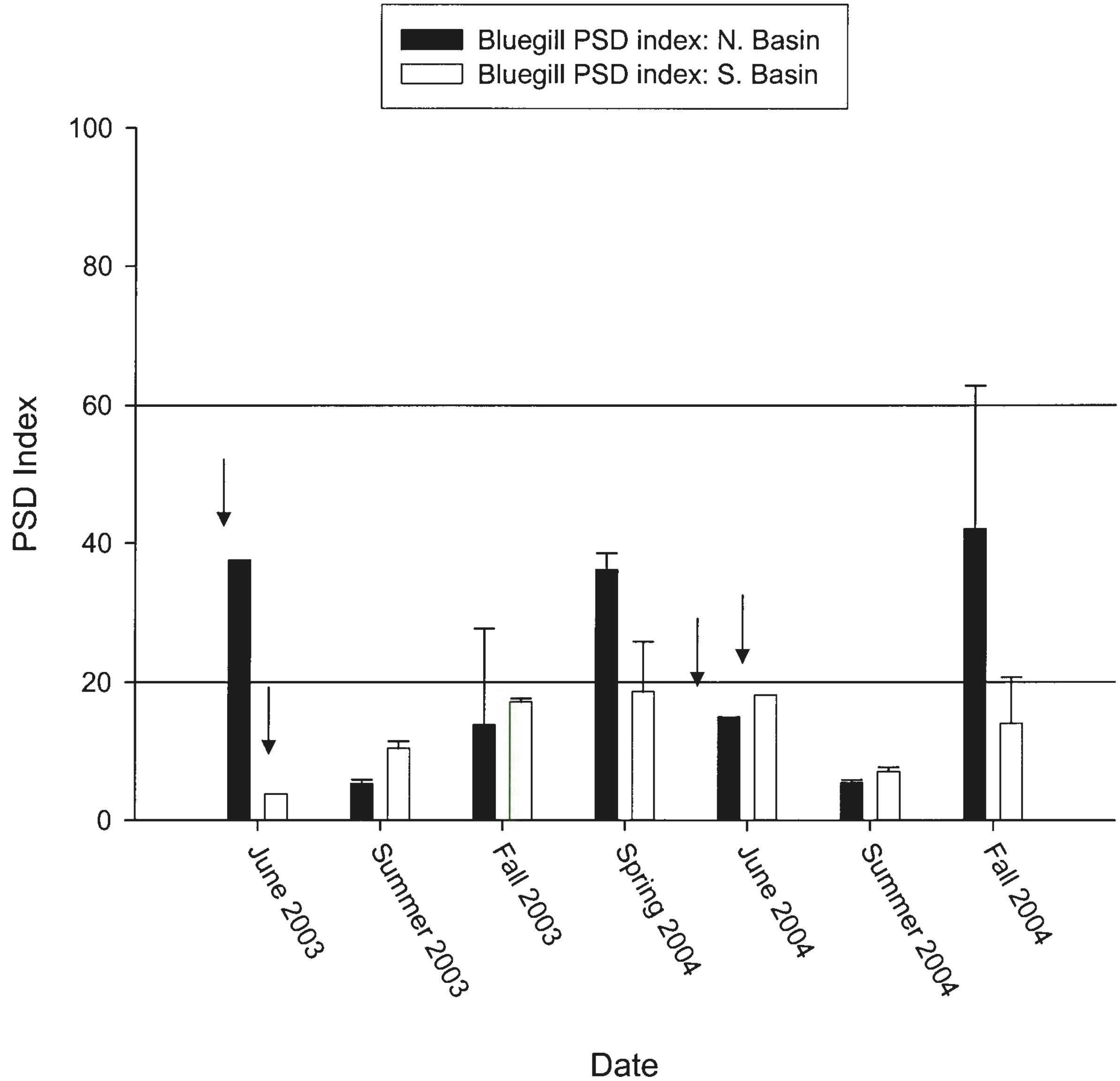


Figure 2.27. Mean proportional stock density (PSD) index (±SE) of electro-fished bluegill in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Reference lines (20-60) indicate desired index ranges (Anderson 1985). Arrow indicates only one monthly mean observation. Stock length (80 mm) and quality length (150 mm) referenced from Anderson (1980).

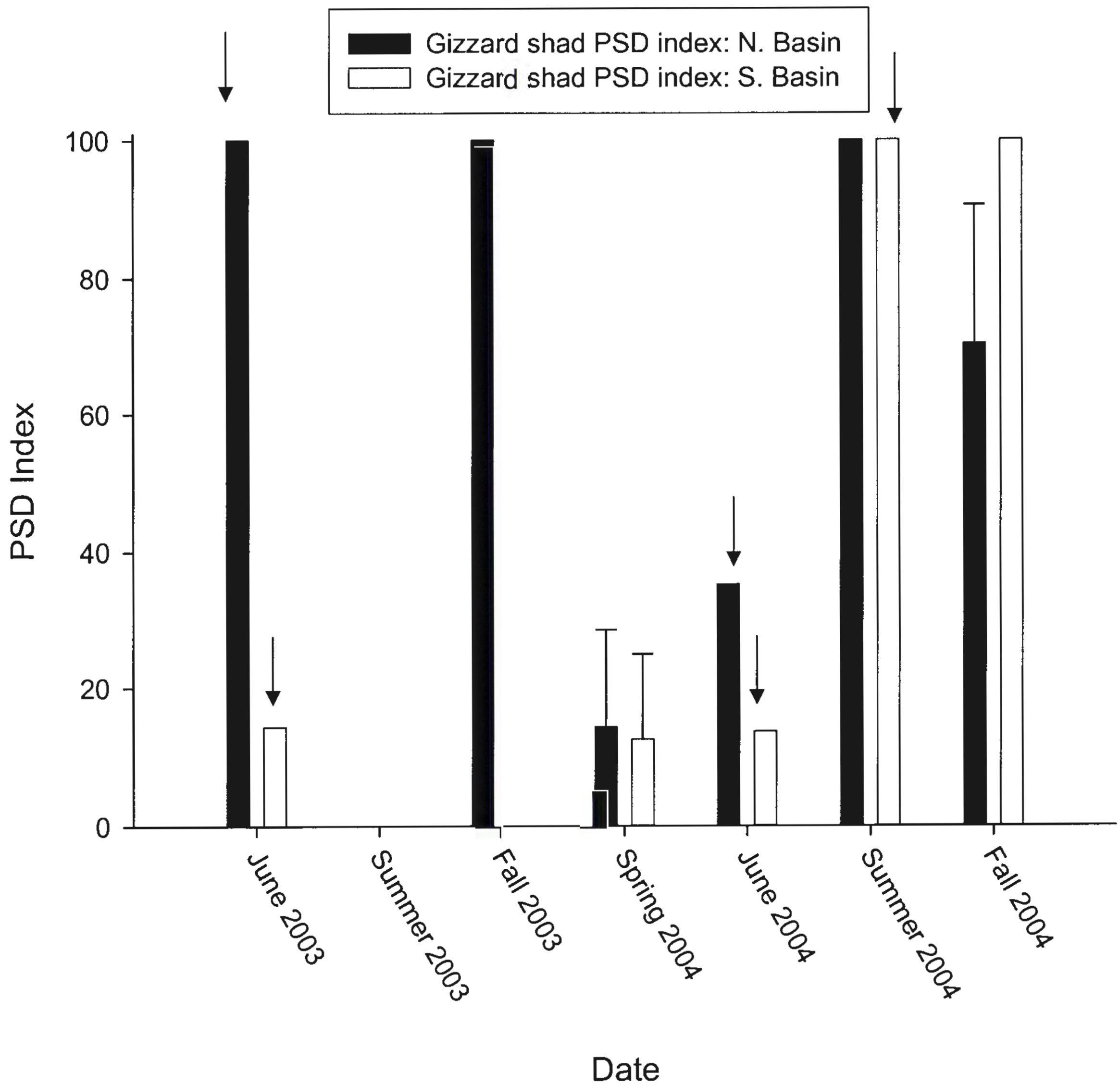


Figure 2.28. Mean proportional stock density (PSD) index (±SE) of electro-fished gizzard shad in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Stock length (180 mm) and quality length (280 mm) referenced from Anderson (1980).

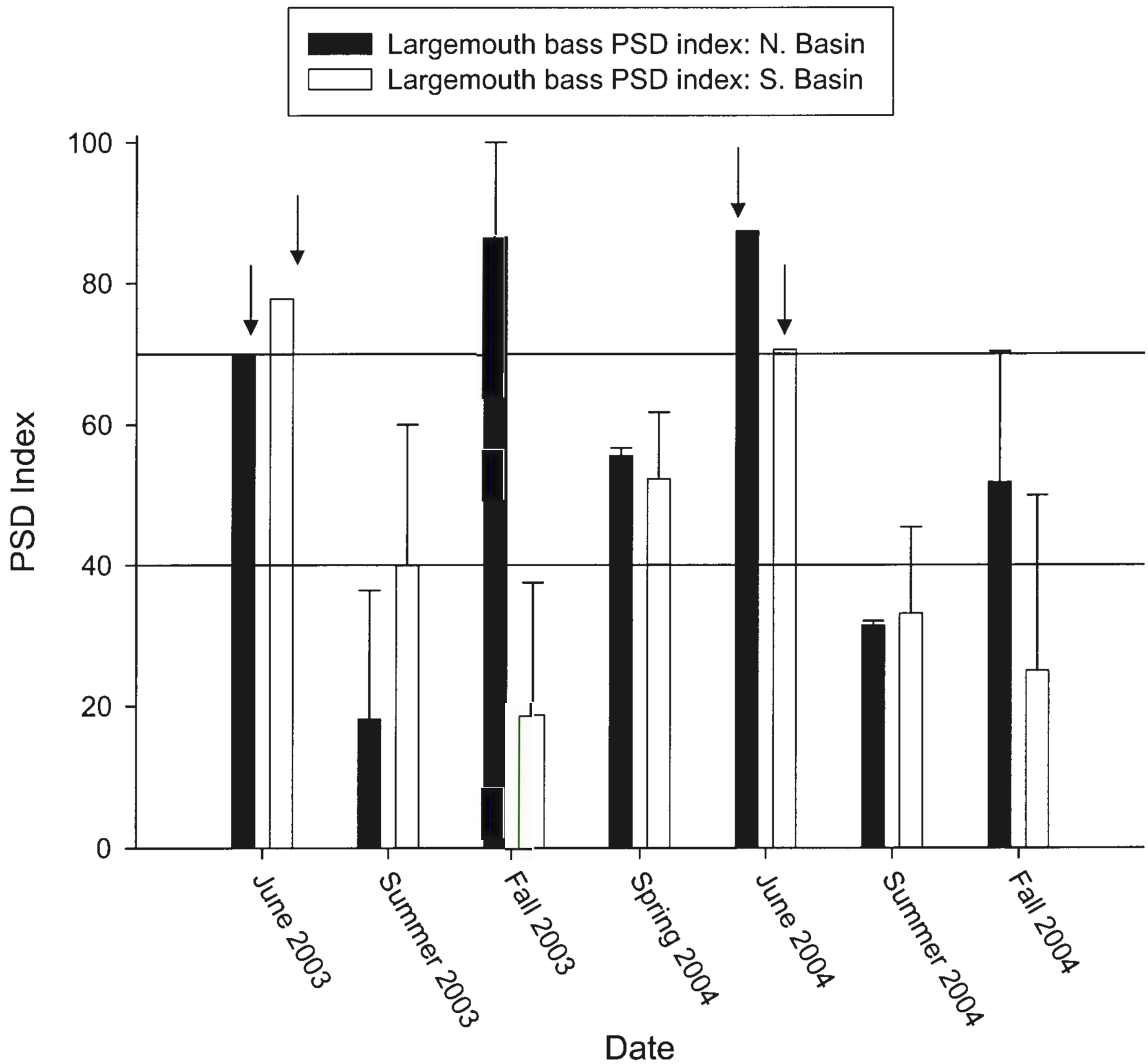


Figure 2.29. Mean proportional stock density (PSD) index (±SE) of electro-fished largemouth bass in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Reference lines (40-70) indicate desired index ranges (Gablehouse 1984a). Arrow indicates only one monthly mean observation. Stock length (200 mm) and quality length (300 mm) referenced from Anderson (1980).

Relative weight (Wr)

Relative weights were normal (near 100) across seasons, basins, and species. There was no significant difference in relative weights of black crappie between basins ($p = 0.682$) or seasons ($p = 0.656$) (Figure 2.30). White crappie (Figure 2.31) also had no significant difference in relative weights across basins ($p = 0.502$) or seasons ($p = 0.652$). The relative weights of bluegill (Figure 2.32) were not significantly different between basins ($p = 0.986$) or seasons ($p = 0.402$). Gizzard shad (Figure 2.33) relative weights were significantly higher in the south basin by approximately 8 % ($p = 0.095$). There was no fall seasonal significant difference in gizzard shad relative weights ($p_{Fall} = 0.270$); summer 2003 was not analyzed, as it was lacking an estimate due to low summer capture rates of gizzard shad. Largemouth bass (Figure 2.34) were not significantly different between basins ($p = 0.179$) or seasons ($p = 0.245$).

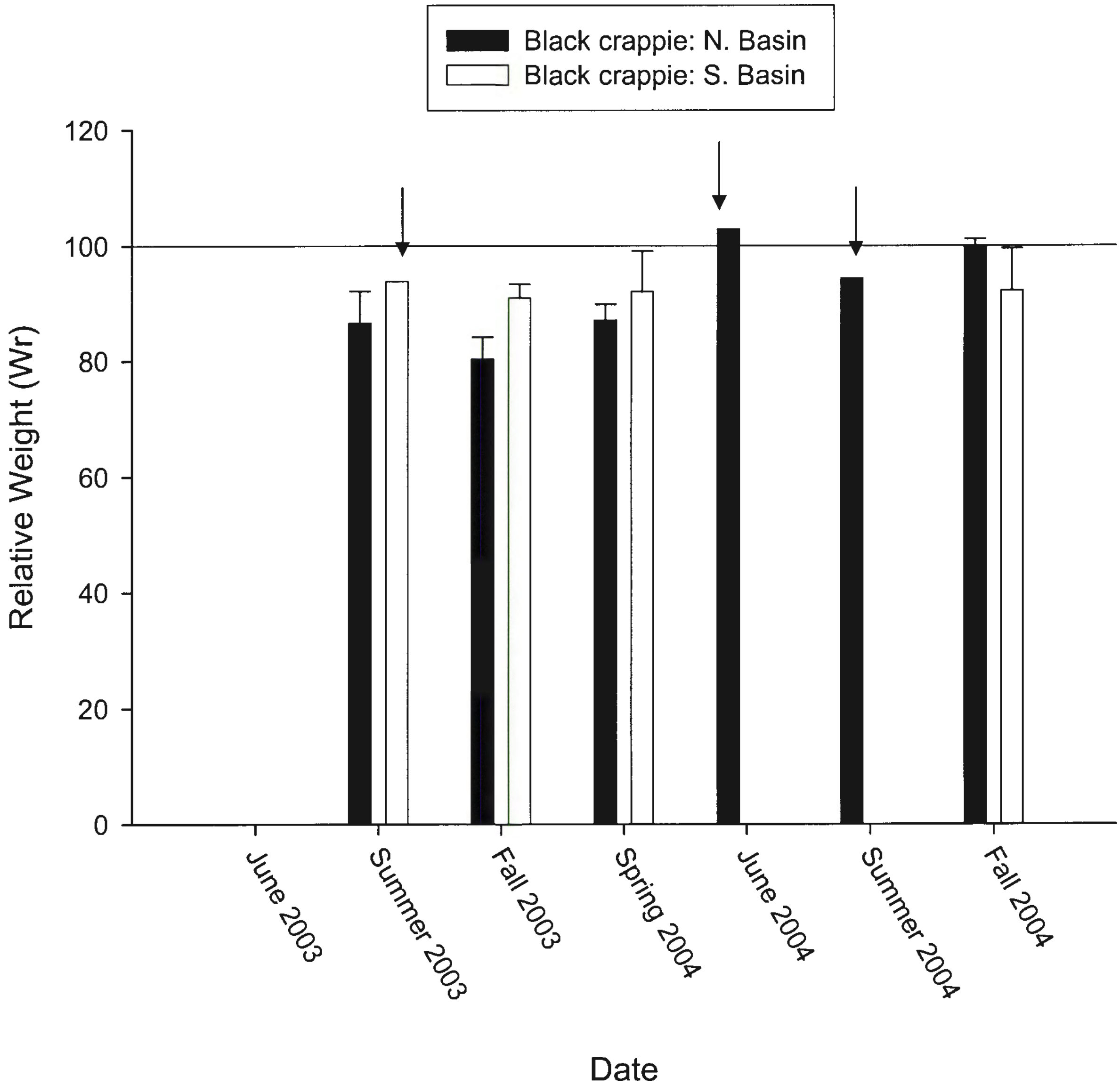


Figure 2.30. Mean relative weights (Wr) (±SE) of electro-fished black crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Reference line (100 Wr) indicates normal index value. Standard Wr equation (Neumann and Murphy 1991), 100 mm total length+: $\log_{10}$ standard weight (g) = -5.618 + 3.345*$\log_{10}$(total length (mm)).

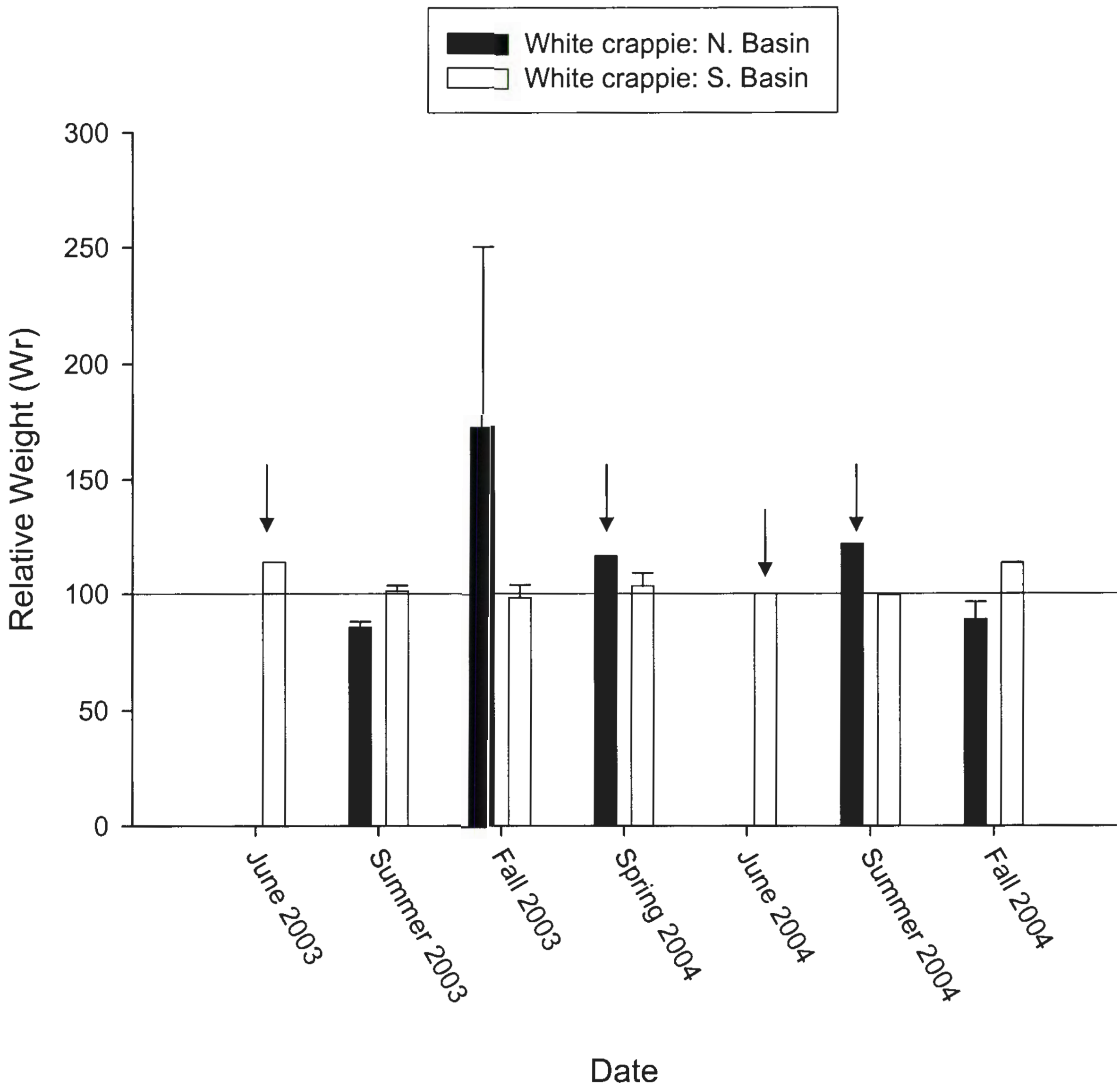


Figure 2.31. Mean relative weights (Wr) (±SE) of electro-fished white crappie in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Reference line (100 Wr) indicates normal index value. Standard Wr equation (Neumann and Murphy 1991), 100 mm total length+: $\log_{10}$ standard weight (g) = -5.642 + 3.332*$\log_{10}$(total length (mm)).

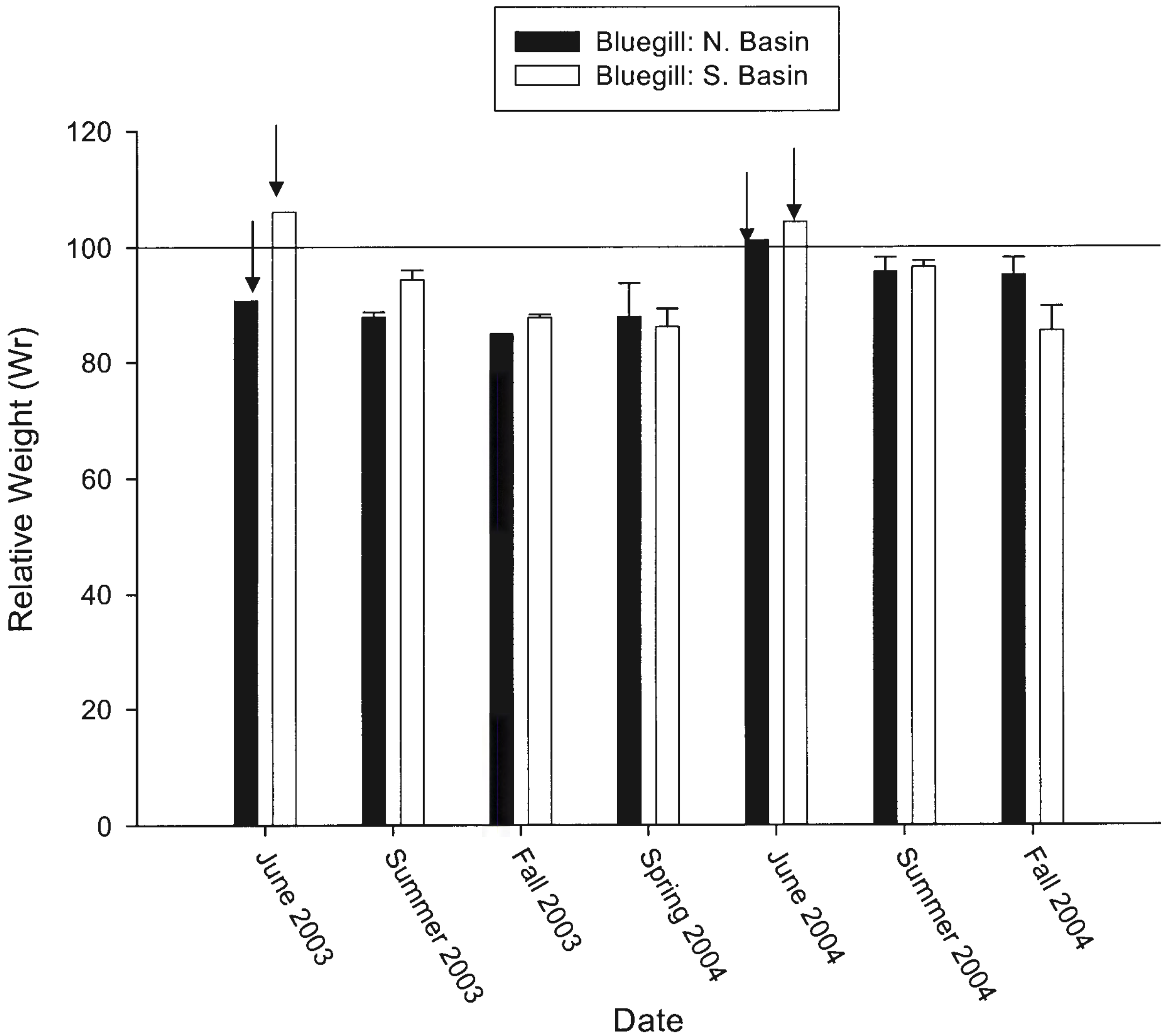


Figure 2.32. Mean relative weights (Wr) (±SE) of electro-fished bluegill in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Reference line (100 Wr) indicates normal index value. Standard Wr equation (Hillman 1982), 80 mm total length+: $\log_{10}$ standard weight (g) = -5.374 + 3.316*$\log_{10}$(total length (mm)).

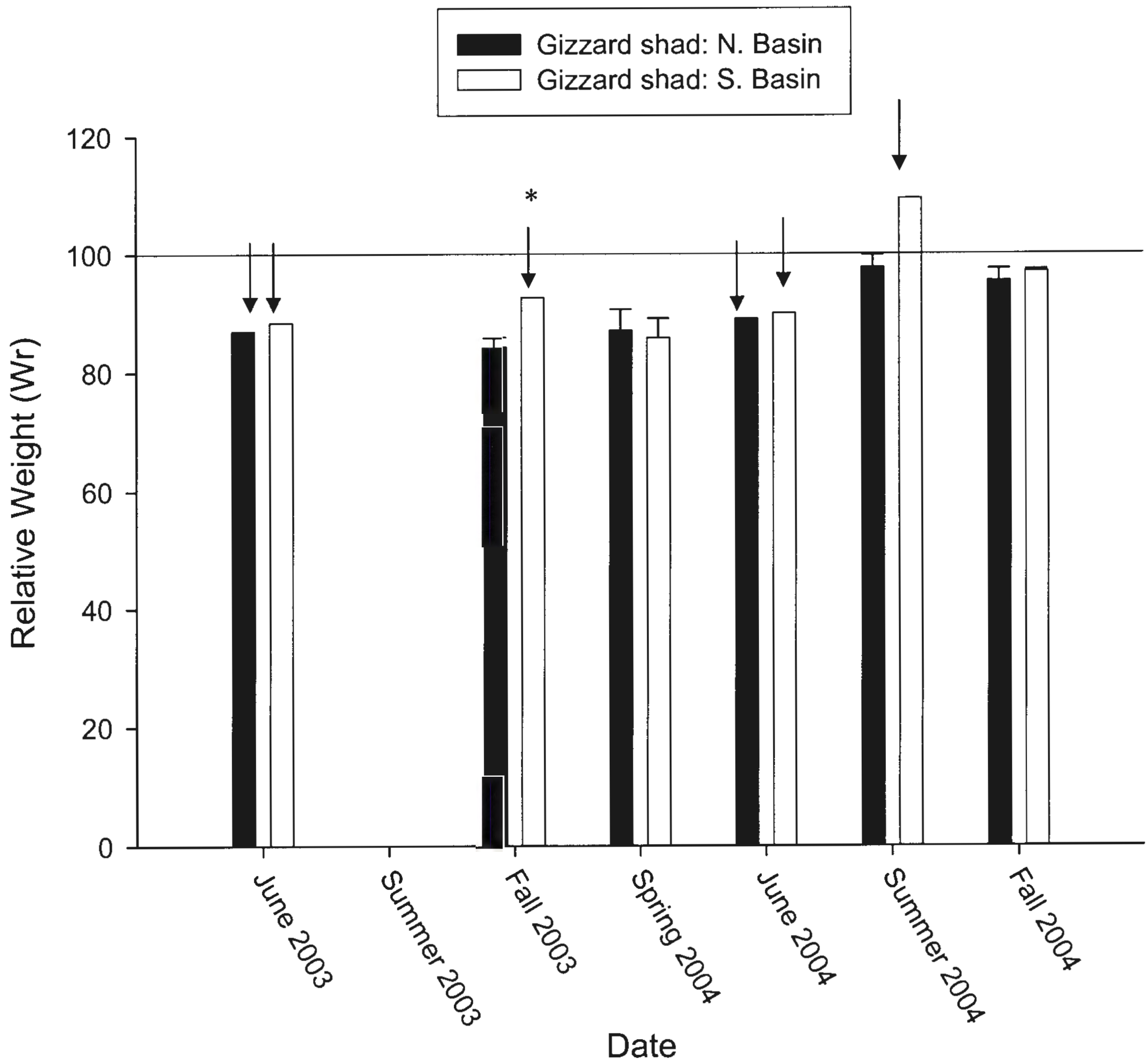


Figure 2.33. Mean relative weights (Wr) (±SE) of electro-fished gizzard shad in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. * = one fish; arrow indicates only one monthly mean observation. Reference line (100 Wr) indicates normal index value. Standard Wr equation (Anderson and Gutreuter 1983), 180 mm total length+: $\log_{10}$ standard weight (g) = -5.376 + 3.170*$\log_{10}$(total length (mm)).

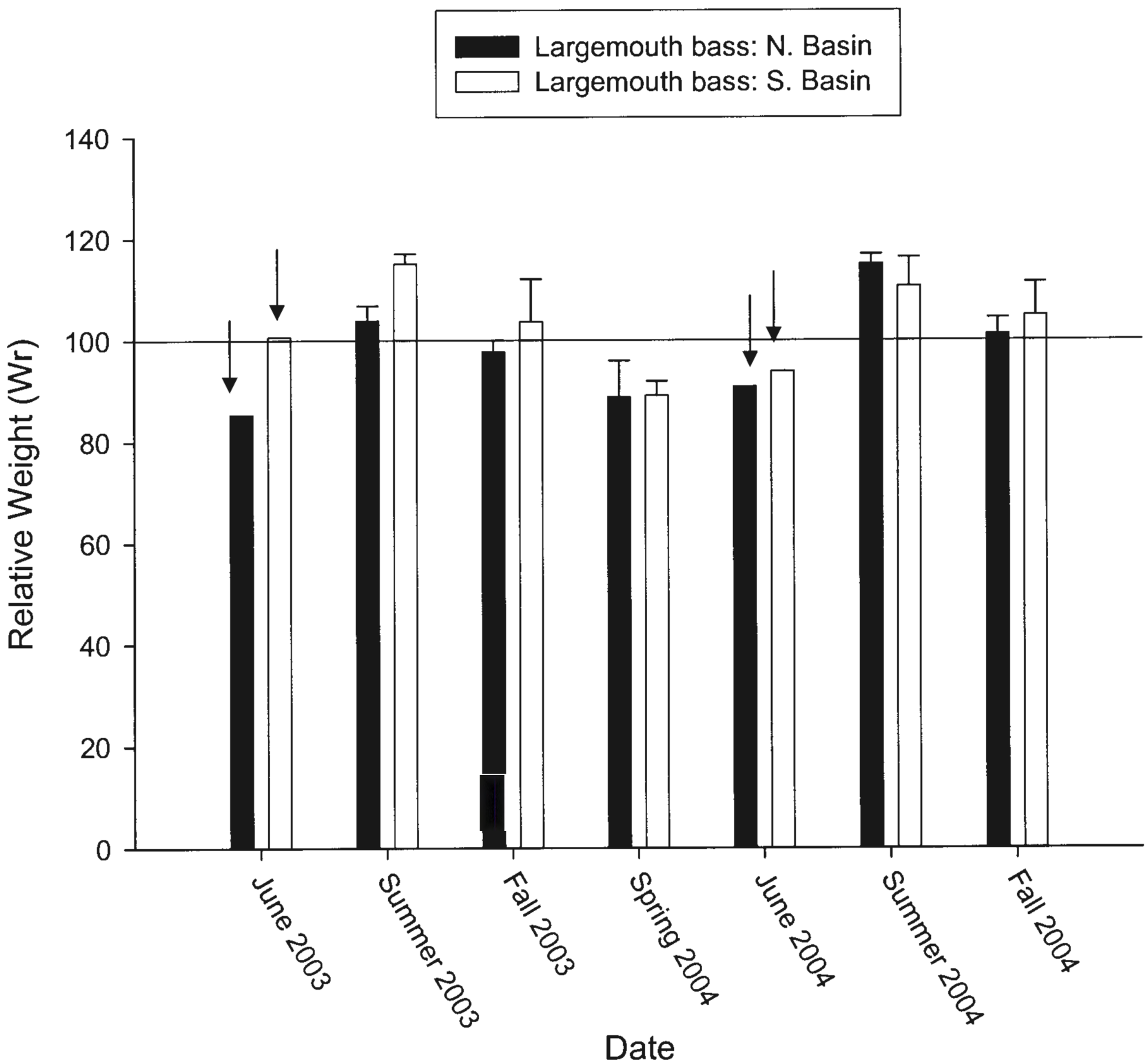


Figure 2.34. Mean relative weights (Wr) (±SE) of electro-fished largemouth bass in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Reference line (100 Wr) indicates normal index value. Standard Wr equation (Wege and Anderson 1978), 150 mm total length+: $\log_{10}$ standard weight (g) = -5.316 + 3.191*$\log_{10}$(total length (mm)).

Growth rates

Growth rates were combined across basins due to no significant differences between basins. Overall, the growth rates of the target species in AHHP were lower then similar age fish found in Iowa. Mean lengths at age compared to Iowa length at age standards (Carlander 1977) for black crappie (Figure 2.35), white crappie (Figure 2.36), bluegill (Figure 2.37), gizzard shad (Figure 2.38), and largemouth bass (Figure 2.39) tended to be lower than the Iowa average length.

Black crappie (Figure 2.35) had a significantly higher back-calculated mean length than white crappie in their first year of growth ($p = 0.081$) (Figure 2.36) but not in their 2^{nd} ($p = 0.285$), or 3^{rd} year ($p = 0.363$).

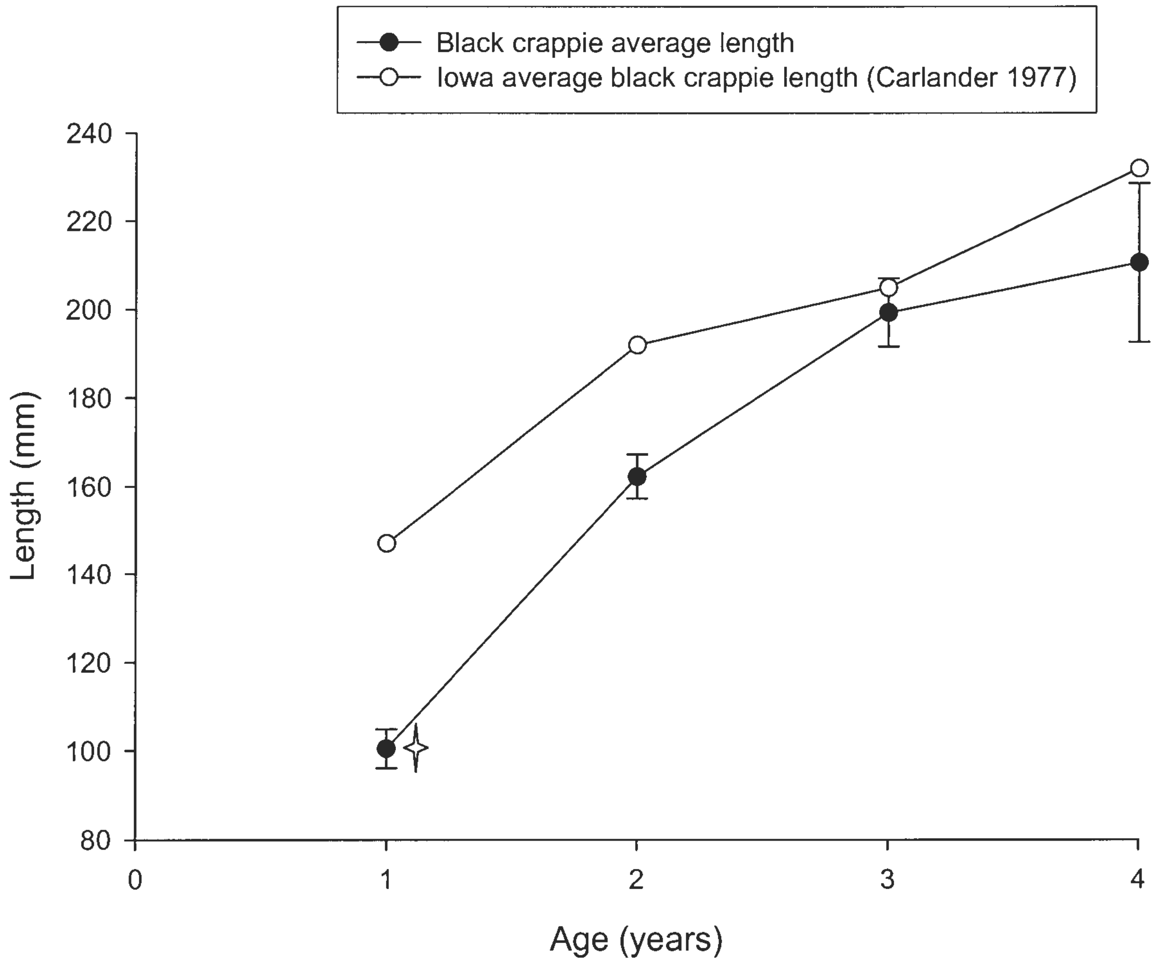


Figure 2.35. Mean length (±SE) of electro-fished black crappie per age class in both basins of Ada Hayden Heritage Park, Ames, Iowa, compared to Carlander (1977), 2004. Star represents a 01. significant difference to white crappie growth (Figure 2.36)

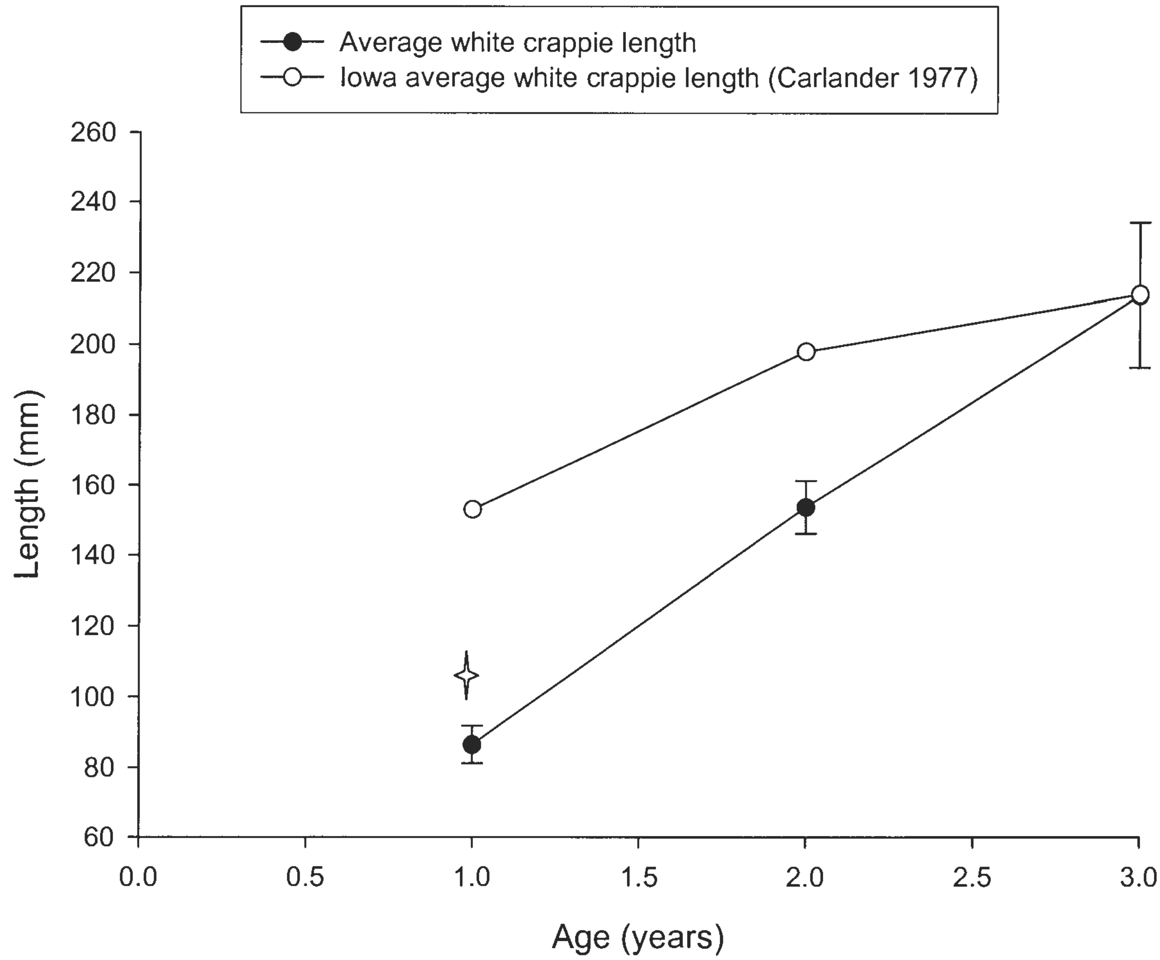


Figure 2.36. Mean length (±SE) of electro-fished white crappie per age class in both basins of Ada Hayden Heritage Park, Ames, Iowa, compared to Carlander (1977), 2004. Star represents a 0.1 significant difference to black crappie growth (Figure 2.35).

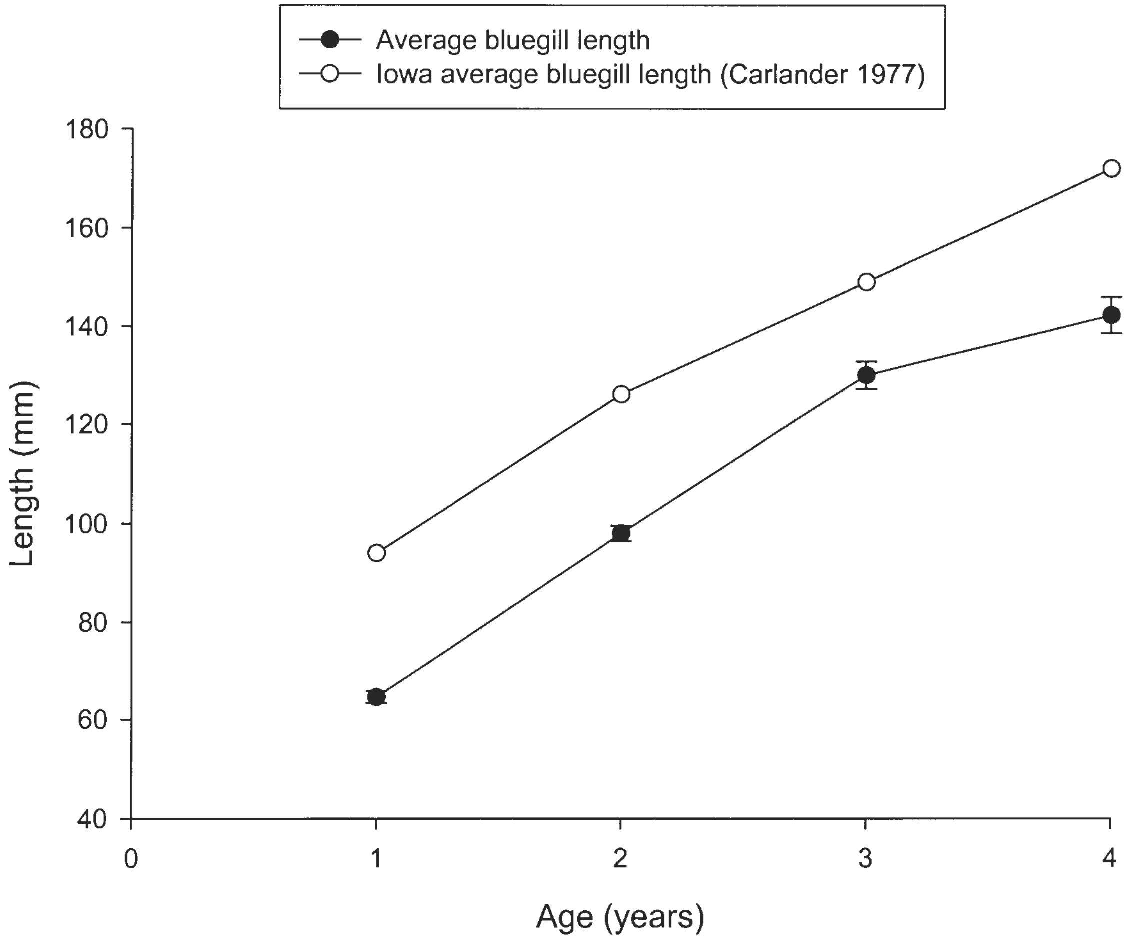


Figure 2.37. Mean length (±SE) of electro-fished bluegill per age class in both basins of Ada Hayden Heritage Park, Ames, Iowa, compared to Carlander (1977), 2004.

Figure 2.38. Mean length (±SE) of electro-fished gizzard shad per age class in both basins of Ada Hayden Heritage Park, Ames, Iowa, compared to Carlander (1977), 2003-2004.

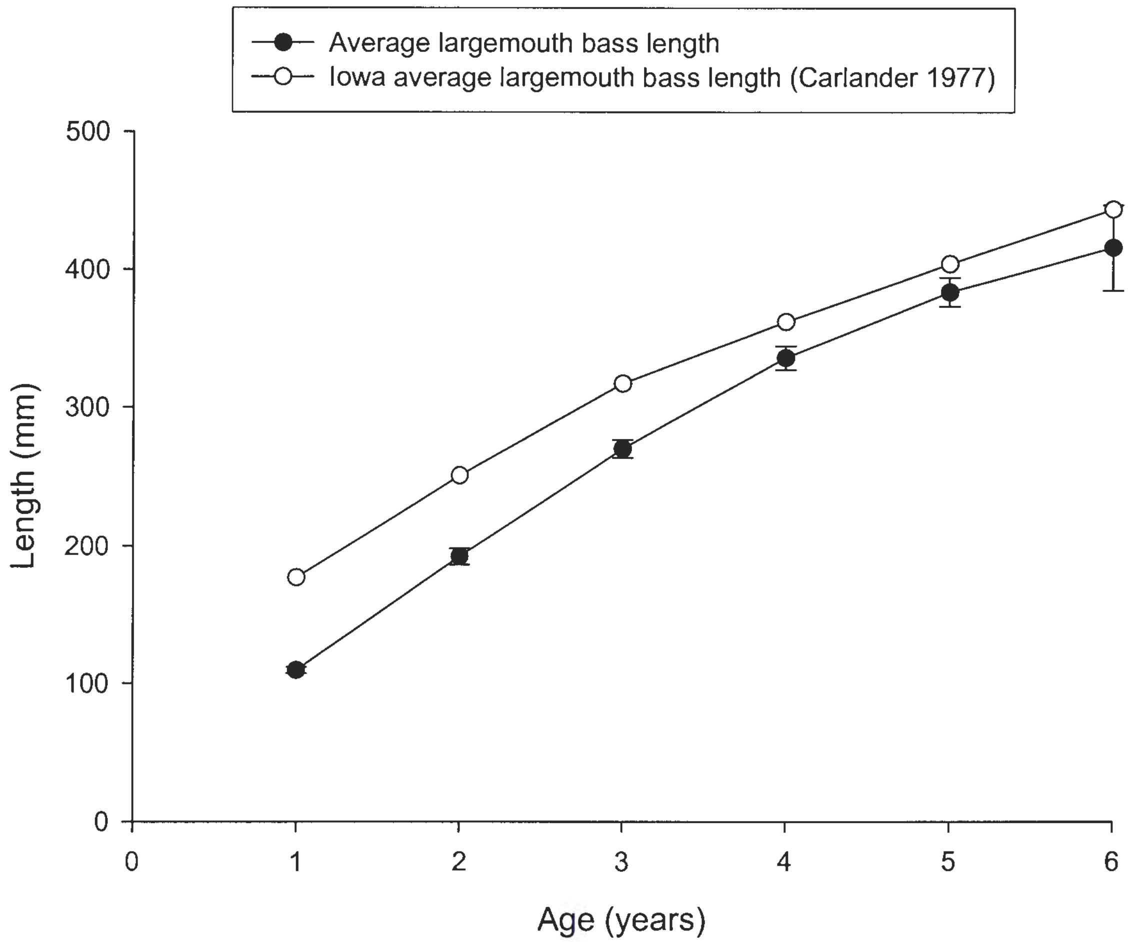


Figure 2.39. Mean length (±SE) of electro-fished largemouth bass per age class in both basins of Ada Hayden Heritage Park, Ames, Iowa, compared to Carlander (1977), 2003-2004.

Largemouth bass stomach analysis

Fifty-three percent of the largemouth bass stomachs sampled were empty. After aging results were completed, largemouth bass were separated into two, total length categories for analysis (200 mm ≤ fish < 300 mm and fish ≥ 300 mm). This separation is approximately equal to the following age groups of the fish (2 to 3 year old fish and 4 year old plus fish).

The percentage of empty stomachs sampled (Figure 2.40) was not significantly different between length categories of largemouth bass ($p = 0.380$) and seasons ($p = 0.685$). There were significant differences in season by basin interactions ($p = 0.023$). Also, the south basin had significantly more empty stomachs than the north basin ($p = 0.052$).

No significant differences of prey items between basins or length categories were discovered in any stomach analysis except for those discussed. Largemouth bass prey items included gizzard shad, other largemouth bass, unidentified fish, Order Anura (frogs), Order Testudines (painted turtles), Family Diptera (flies), Family Hemiptera (true bugs), Family Ephemeroptera (mayflies), Family Plecoptera (stoneflies), and Order Decapoda (crayfish). While largemouth bass rely heavily upon fish as a food source (Figure 2.41), fish in this lake had gizzard shad significantly occur in 20% more of the stomach analyses in fall 2004 compared to fall 2003 ($p < 0.002$). Diptera occurred significantly more in the north basin ($p = 0.033$), in 35% more of the sampled stomachs in summer 2004 compared to summer 2003 ($p = 0.040$), and did not significantly differ between length categories of largemouth bass ($p = 0.665$). Unidentifiable fish occurred significantly more in the north basin (p

= 0.013), significantly less in fall 2004 (p = 0.016), and significantly more in the younger size category (p = 0.008). Total occurrence of fish was significantly higher in the north basin (p = 0.0089), significantly higher in small fish (p = 0.082), but was not significantly different between comparable seasons (p_{Summer} = 0.927) (p_{Fall} = 0.849). Further, frequency of occurrence analyses between seasons and basins including: cannibalism, hemipterans, ephemeropterans, unidentifiable insects, total insects, snails, painted turtles, and all non-fish prey items were either highly insignificant or were not analyzed due to missing basin estimates.

Stomach analysis by weight and volume revealed no significant differences between basins or length category for any food item (Figure 2.42). The average largemouth bass in fall 2004 had approximately 2 g more gizzard shad in its stomach analyses than in fall 2003 (p = 0.009). Further, stomach analyses by weight, between seasons and basins including: cannibalism, unidentifiable fish, total fish, hemipterans, ephemeropterans, unidentifiable insects, total insects, snails, painted turtles, all non-fish prey items, and all prey items were either highly insignificant or were not analyzed due to missing basin estimates.

The average largemouth bass in fall 2004 fed upon gizzard shad significantly more by approximately 2 mL than in fall 2003 (p = 0.027); estimates were unable to be calculated for the summer season. Further, volume stomach analyses between seasons and basins including: cannibalism, unidentifiable fish, total fish, hemipterans, ephemeropterans, unidentifiable insects, total insects, snails, painted turtles, all non-fish prey items, and all prey items were either highly insignificant or were not analyzed due to missing basin estimates.

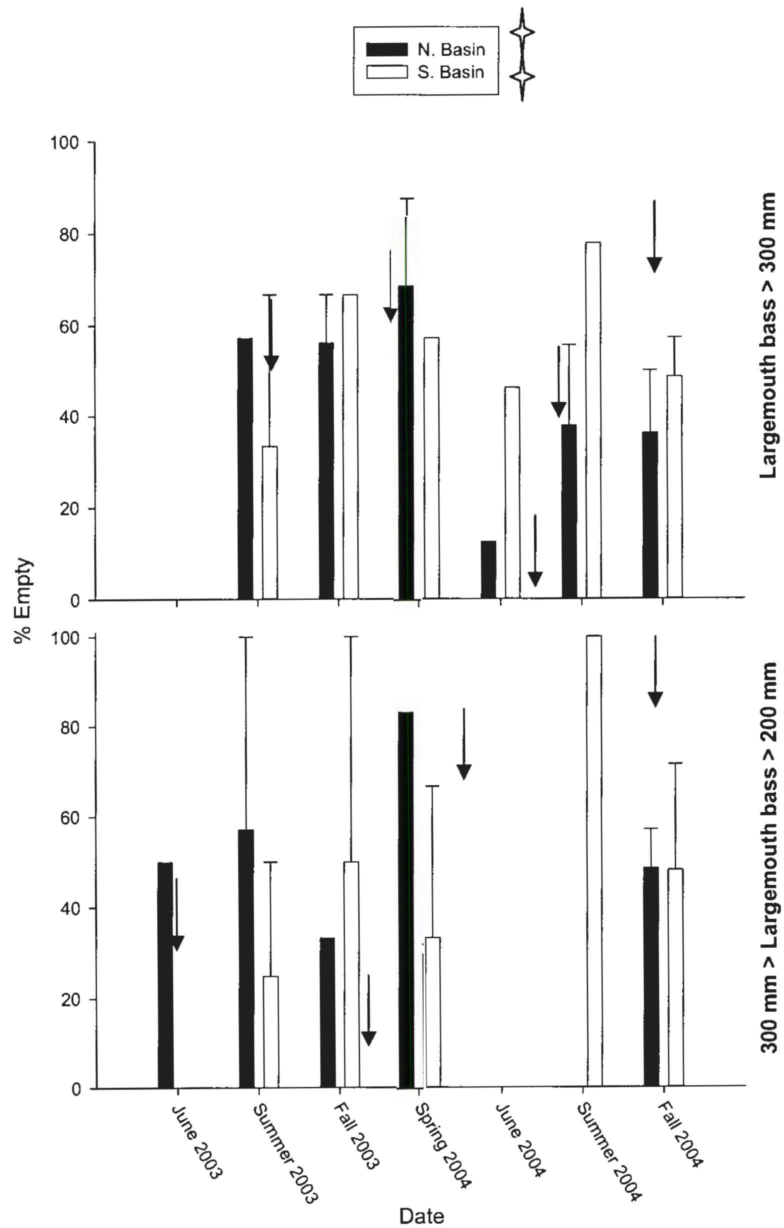


Figure 2.40. Percentage of empty electro-fished largemouth bass stomachs by total length categories, sampled in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Arrow indicates only one monthly mean observation. Star represents a 0.1 significant difference.

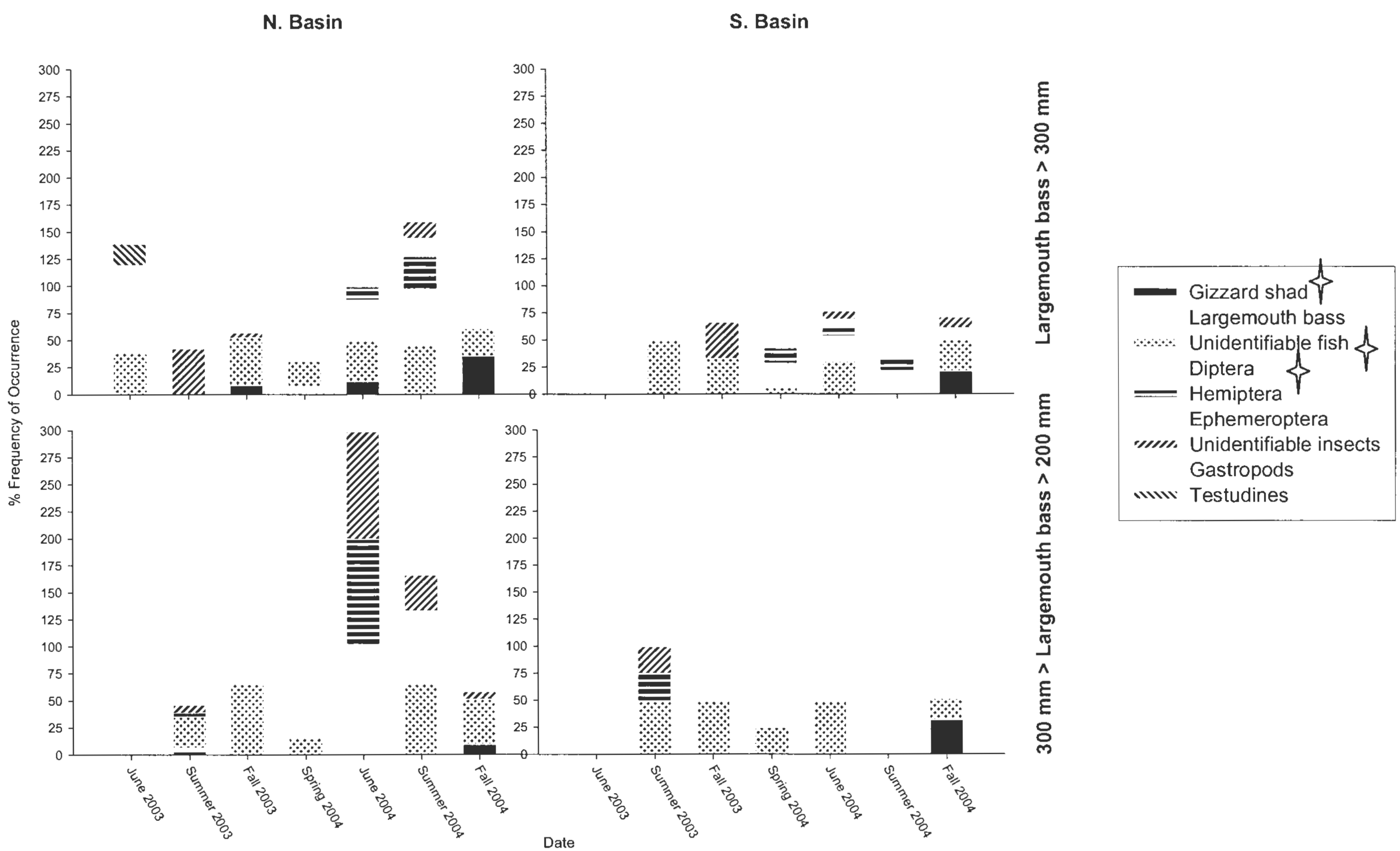


Figure 2.41. Percent frequency of occurrence of prey items in electro-fished largemouth bass stomachs by total length categories, sampled in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Star represents a 0.1 significant difference.

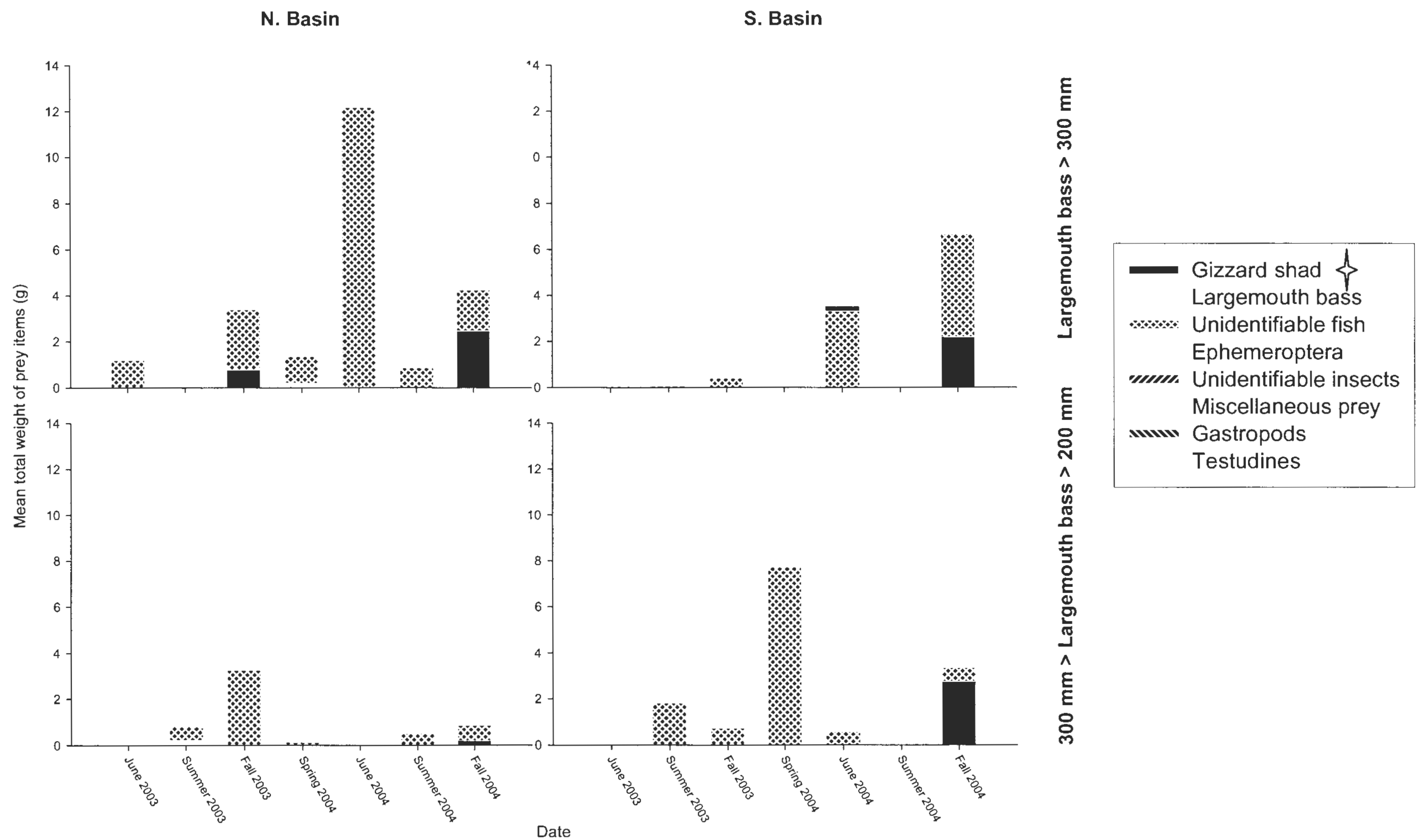


Figure 2.42. Mean total weight (g) of prey items in electro-fished largemouth bass stomachs by total length categories, sampled in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Star represents a 0.1 significant difference.

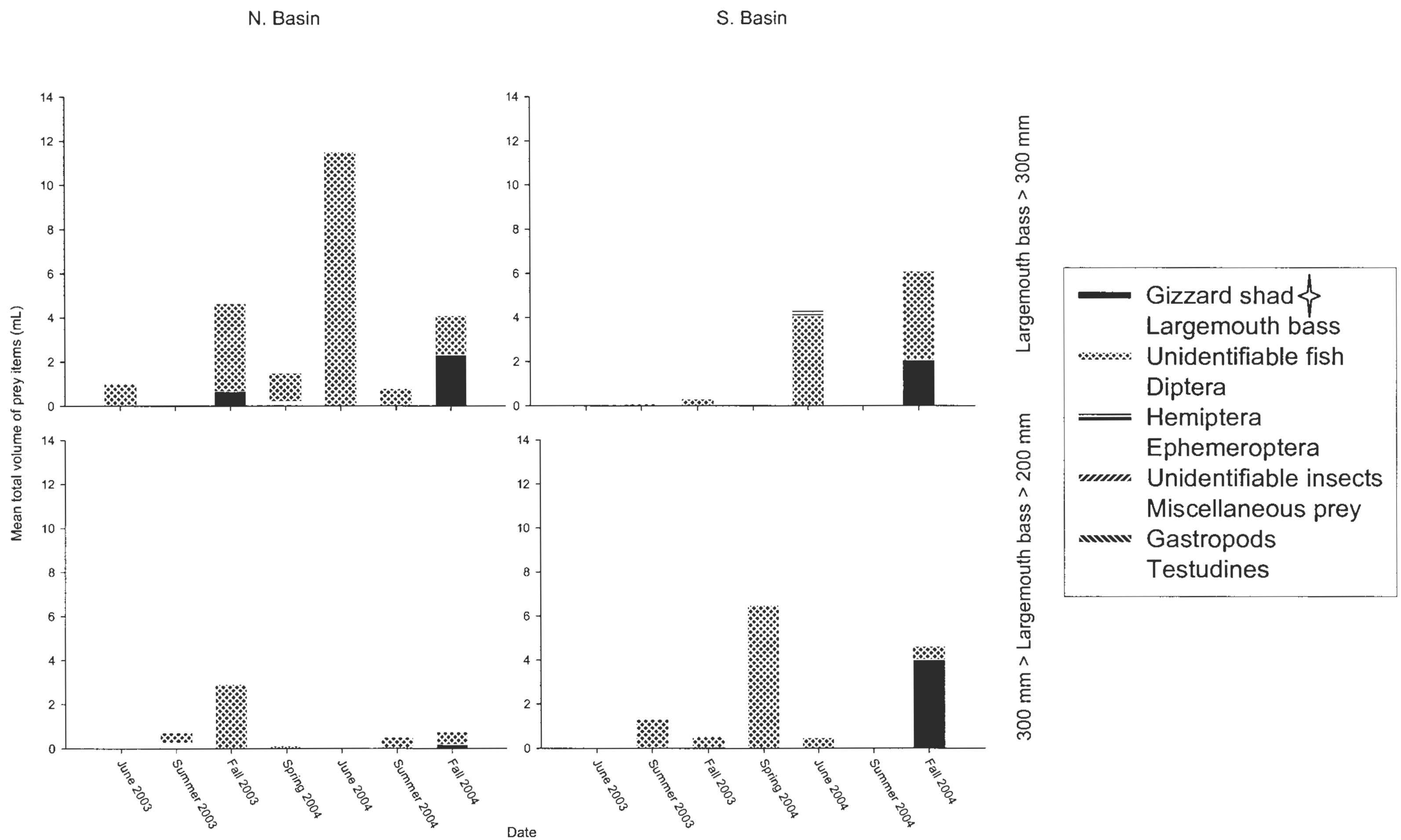


Figure 2.43. Mean total volume (mL) of in electro-fished largemouth bass stomachs by total length categories, sampled in the north and south basin of Ada Hayden Heritage Park, Ames, Iowa, 2003-2004. New exploitation began on July 1, 2004. Star represents a 0.1 significant difference.

Discussion

Species diversity and richness

Ada Hayden Heritage Park has a very tremendously diverse fish fauna (32 taxa) which is uncharacteristic of most midwestern fisheries. Typical midwestern waterbodies consist of largemouth bass, bluegill, and channel catfish, a complex that dates back to early fisheries management research (Bennett 1950, 1952, 1971; Carlander 1952; Swingle 1950, 1956). The presence of this large diversity limits the overall productivity of desired sport fish species by harboring energy in otherwise less desirable species, e.g., buffalo, carpsuckers, and gizzard shad. Gee (1976) recommended reduction of species diversity to maximize sport fish production in gravel-pit lakes in south-east England.

Many of the species are lotic species, probable past introductions through flooding of the nearby Skunk River into the waters of AHHP, and some species have most likely originated from angler introductions. During sampling runs in August 2004, 2 months post-exploitation, a hybrid striped bass was sampled and a northern pike was seen but not boated. Current public ownership and additional park usage may result in additional angler introductions, further reducing the production of desirable fish species.

Smallmouth bass *Micropterus dolomieui* were also sampled for the first time after exploitation occurred. However, this was most likely a recent stocking by the city of Ames parks and recreation personnel that consisted of 1,800 70 to 100-mm age-0 fish (Nancy Carroll, Director Ames Parks and Recreation Department, Ames, Iowa, personal communication). We can't be certain this catch wasn't a natural occurrence as the stocked smallmouth bass were not marked. A stocking validation program is recommended to ascertain the viability of further stocking of smallmouth bass or other species into this quarry.

Surprisingly, more white crappies were sampled than black crappies. White crappies have been noted to be more prevalent and better adapted to warmer, turbid waters (Neal 1963; Ellison 1984) than black crappies. Thus, the crappie population is reverse of the norm in AHHP. However, fall CPUE of black crappie was higher than white crappie and remaining CPUE and relative weight analyses were not significantly different between the two species indicating that differences in species abundance may be just a natural variation.

Any difference in crappie species abundance that does exist may be due to a number of factors, such as gear bias. Sammons et al. (2002) found that electro-fishing samples from Tennessee reservoirs had higher proportions of white crappie to black crappie than samples from trap nets. Second, many age-0 white crappie were captured in 2003 (Figure 2.21); including only the adult fish in species comparisons would lessen the dramatic comparison. Finally, there is evidence of no biological relationship between crappie species proportions and turbidity. A recent study using a series of ponds under varying turbidity levels did not find any significant growth difference between white and black crappie (Spier and Heidinger 2002); thus, the differences in species abundance of black and white crappie may be less than sampled and/or not surprising.

Population and biomass estimates

Population estimates were attempted on black crappie, bluegill, largemouth bass, and white crappie. However, no recaptures were obtained on either of the *Pomoxis* species. Possible reasons for no recaptures include the limited structure available, the limited size of the littoral zone, and the depth of the quarry. The only habitat available to most fish is depth but electro-fishing gear is best used in shallow water areas (McInerny and Cross 2000). Thus, fewer shallow areas inhibit the electro-fishing gear's effectiveness. Further, the waters of AHHP have moderate conductivity, ranging from 331 to 440 mS/cm; this conductivity can inhibit the effectiveness of the electrofishing unit (McInerny and Cross 2000) as well. Also, Schneider (1971), as cited in Goedde and Coble (1981), found that using electro-fishing, as the only gear type, yielded mark-recapture population estimates that were consistently lower than estimates using more than one gear type. However, Jesian (1977) found little difference in white sucker population estimates from electro-fishing alone.

Also, our population estimates were based on recaptures from both the unexploited and exploited sampling periods. This violates a major assumption of the population estimate, that no individuals are removed from the population during the population estimate sampling period. We, thus, caution that population/biomass estimates based on low recapture numbers and over a period of exploitation could be possibly skewed. Therefore, the estimates should be viewed with those acknowledgements.

The biomass estimates of bluegill and largemouth bass in Ada Hayden are low. Bluegill and largemouth bass estimates in Ada Hayden were 7 kg/ha and 8 kg/ha, respectively. Typical bluegill biomass estimates in Iowa and Illinois ranged from 100-450 kg/ha (Carlander 1977). Largemouth bass biomass estimates in a northern Michigan lightly exploited lake (Clady 1975) were 20 kg/ha. George Wyth and Casey Lake in northeast Iowa in 2003 had 10 kg/ha and 65 kg/ha respectively (Bryan Hayes, Iowa Department of Natural Resources, unpublished data). AHHP relates more toward George Wyth, a borrow pit, and its lower biomass estimates while Casey Lake is a reservoir. Borrow pits, quarries, and natural lakes are typically less productive than reservoirs due to smaller drainage areas, and thus produce a lower fish biomass (Whittier et al. 2002). In comparison to other associated waters, biomass estimates of AHHP show the limited capacity of productivity present in the lakes.

The limited production could be due to AHHP being a quarry lake as they are typically less productive waters. Downing and Kopaska (2002) classified Ada Hayden's waters as mesotrophic. As mentioned earlier, AHHP waters are among the best quality (least fertile) in Iowa. However, the high quality, low nutrient waters of Ada Hayden cascade up through the trophic system, leading to lower amounts of production by fish species. Water temperature can effect growth of fishes, however, the mean water temperature of AHHP is close to most Iowa lakes despite the depth of AHHP. Thus, the lake is limited in production capacity by its high water quality.

Catch per unit effort (CPUE) (catch/hour)

Number of fish caught per hour was extremely variable through all species; only gizzard shad were significantly different in the CPUE model incorporating species. We hypothesized that angler exploitation would decrease the CPUE due to harvest and angling mortality of predator fishes and increase the CPUE in prey fishes due to fewer predators. Largemouth bass CPUE decreased by approximately 70 fish/hour in 2004. However, exploitation was not the cause; a greater number of age-0 largemouth bass caught in 2003 (Figure 2.24) resulted in the apparent decrease in CPUE in 2004. Reproduction was excellent in 2003 for all species. Thus, there were no significant differences in CPUE between seasons for any species related to exploitation.

Proportional stock density

We hypothesized that there would be a decrease in the PSD values for sport fish species as larger individuals were harvested. Black crappie actually significantly increased their PSD value by approximately 50 index units from summer 2003 to summer 2004. No other species showed any significant differences between basins or seasons. However, the PSD value for summer 2004 in black crappie is based on only one basin; thus, comparison is weak. Further, gear bias may be another factor. Electro-fishing has been shown to have a selective bias toward larger crappie (Sammons et al. 2002). This bias may have been accentuated by other confounding natural variables in the field. Exploitation in this project has not changed the length-structure or PSD values of AHHP sport fish, as exploitation did in Goedde and Coble (1981).

Black crappie and gizzard shad frequently had maximum PSD values indicating there were only larger fish present. We do acknowledge that many PSD values are based from less than recommended numbers (see length-frequency distributions); however, low catch rates dictated most of those problems. Most black and white crappie PSD values were near 100, indicating the population recruits few individuals to the stock size (130 mm). The lowest PSD value of crappie species occurred in the summer of 2003 but was still higher than the recommended 20-40 (Gabelhouse 1984b). Mean values of both crappie species (Table 2.14) were also both higher than the recommended ranges. In spite of these high PSD values, crappie species were not easily caught. We speculate that a lack of habitat caused crappies to mostly suspend in the middle of the lake.

O'Brien et al. (1984) indicated that crappies are primarily a pelagic species. A boat mounted sonar unit indicated many fish suspending in open water on no structure during fall 2004 in AHHP. Also, Sammons et al. (2002) consistently caught larger crappie with electro-fishing gear than trap nets. Therefore, PSD values for this species may not be indicative of what is truly present due to both low catch rates and gear bias.

Crappie reproduction may be variable at Ada Hayden because 2003 was the only year any substantial crappie reproduction was noted. However, we can not definitively conclude limited crappie reproduction based on only a 2-year study.

Bluegill PSD values (Figure 2.27) are generally less than the recommended range of 20 to 60 (Anderson 1985), indicating the population is not recruiting to the larger size classes. The overall mean bluegill PSD (Table 2.14) is also less than 20.

Population estimates are lower than normal, making intraspecific competition very unlikely. Relative weights of bluegill are not unduly low; however, they do not reach 100 very often, indicating a relatively less desirable condition. Stomach analysis of largemouth bass did not indicate any presence of identifiable bluegills. Over harvest by humans is unlikely due to past private ownership of AHHP, so over exploitation by any predator, human or fish, is unlikely. Thus, the AHHP bluegill fishery is unbalanced with higher numbers of smaller fish.

Growth analysis indicates that all target species in AHHP are growing slower than normal Iowa waters, including bluegills. This would easily decrease the PSD value for bluegills. Mittelbach and Osenberg (1993) described the ontogenetic shift in adult bluegill to zooplankton from littoral benthic invertebrates and a positive relationship in adult bluegill growth to zooplankton density. Thus, smaller bluegills need a well vegetated littoral zone. Low amounts of shallow littoral zone habitat in AHHP decrease the proper refugia and prey younger bluegills need (Mittelbach 1981), and also, capture efficiency (McInerny and Cross 2000) for the electro-fisher is decreased.

While zooplankton measurements were not taken at AHHP, interspecifc competition from gizzard shad filter feeding and feeding by the remaining diverse fish community would decrease available zooplankton and growth of bluegill. This further lowers PSD values in bluegills. Competition, lack of habitat, and slow growth remain the most likely cause of the bluegill population structure imbalance. Increasing littoral zone and woody habitat should help with this structure imbalance, but the slow growth is inherent to AHHP and can not be changed without drastic measures.

Gizzard shad PSD values were quite variable. Most seasons, PSD values were at 100, while at other seasons values were less than 20. Michaletz (1998b) found that most Missouri reservoirs had PSD values less than 20. Low seasons of PSD values occurred at the beginning of the year in AHHP. High PSD values represent that only older fish were sampled later in the season; we are unsure why this occurred. Overall, the gizzard shad catch in AHHP was too variable to use PSD values as an index of population balance.

Largemouth bass would be expected to have PSD values between 40 and 70 (Gablehouse 1984a). However, PSD values in AHHP varied from below, within, and above these recommendations of balance (Figure 2.29). June of both years indicates there were more quality sized fish than desired in the population while the summer PSD values had generally less quality sized fish than desired. Overall, the population appears to be balanced with a mean PSD value of 47.

Relative weight

Relative weights of all species did not significantly change after exploitation. White crappie show considerable deviations from the standard value of 100. While the data have been repeatedly checked for accuracy, the fall 2003 white crappie relative weight values (Figure 2.31) are likely the result of human error in the field, such as data gathering or recording. Ideal weights in bluegills were slightly less than desirable, most likely due to interspecific competition from gizzard shad and limited habitat, as discussed earlier. Most species, however, had good condition factors, making food availability not a management issue for this quarry except in issues related to gizzard shad.

Largemouth bass stomach analysis

We were curious about possible changes in the diet of largemouth bass due to new angling exploitation effects on largemouth bass behavior and prey species. Largemouth bass did have significantly more gizzard shad in their diet in fall 2004 than fall 2003. Noble (1981) defined the key problem in forage fish management as maintaining prey size within vulnerable ranges. If more gizzard shad were present in the diet of largemouth bass during fall 2004, one would expect a shorter length to be present during that time or abundance to be greater. However, the length of age-0 gizzard shad was did not appear to change between comparable seasons (Figure 2.23); consequently age-0 fish were not vulnerable longer during 2004. Further, we would expect more age-0 gizzard shad to be present in 2004; however, there was no difference in age-0 gizzard shad CPUE from 2003 to 2004. In 2004, 59 stomachs were analyzed; in 2003, 24 stomachs were analyzed. Thus, 2003 may yield estimates that are not as precise or accurate as in 2004 due to a lower sample size. Even though significantly different, the difference in sample sizes and natural variation may account for the differences between years of gizzard shad occurrence in largemouth bass stomach samples.

This study was initially proposed at a time when the exploitation was scheduled to begin in November 2003, including an ice fishing season. Ice fishing anglers can rapidly exploit a fishery (Havey and Locke 1980) and have been noted to retain more of the caught fish than open water anglers (Margenau et al. 2003).

The 4-month, studied exploitation period at AHHP has probably been merely not enough time to detect or cause changes. With a lowered effect from less exploitation time and only two experimental units, our statistical power may be low. Further, estimated harvest by anglers in AHHP was lower than expected for a new fishery, as speculated by Fowler (2005a), causing less of an impact over time. With additional time, post-exploitation fisheries surveys may detect future changes in diet of the largemouth bass and other AHHP fishery variables due to angling exploitation.

Conclusion

AHHP can be characterized as a gravel quarry pit with limited littoral zone, low fertility, limited habitat, low sport fish productivity, slow growth, and overly high species diversity with the presence of gizzard shad. No major angler impacts except for probable species introductions after 4 months of new exploitation were detected in AHHP using length frequencies, PSD values, CPUE, relative weights, and largemouth bass stomach analysis. However, future data may show a detectable change.

Acknowledgements

We would like to thank all the technicians, volunteers, and graduate students whose technical assistance and advice made this project possible. We would also like to thank the city of Ames for the great cooperation in allowing us study Ada Hayden Heritage Park. Dick McWilliams of the Iowa Department of Natural Resources helped tremendously with advice and assistance throughout the project.

Literature Cited

Allen, M.S., J.C. Greene, F.J. Snow, M.J. Maceina, and D.R. Devries. 1999. Recruitment of largemouth bass in Alabama reservoirs: relations to trophic state and larval shad occurrence. North American Journal of Fisheries Management. 19:67-77.

Allen, M.S., M.V. Hoyer, and D.E. Canfield, Jr. 1998. Factors related to black crappie occurrence, density, and growth in Florida Lakes. North American Journal of Fisheries Management 18:864-871.

Anderson, R.O. 1980. Proportional stock density (PSD) and relative weight (W_r): interpretive indices for fish populations and communities. Practical fisheries management: more with less in the 1980's. *in* S. Gloss and B. Shupp editors. Proceedings of the 1st Annual Workshop of the New York Chapter American Fisheries Society. (Available from New York Cooperative Fishery Research Unit, Ithaca, New York

Anderson, R.O. 1985. Managing ponds for good fishing. University of Missouri Extension Division, Agricultural Guide 9410, Columbia.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Anderson, R.O. and S.J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 283-300 *in* L.A. Nielsen and D.L.. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Arbuckle, K.E. and J.A. Downing. 2001. The influence of watershed land use on lake N:P in a predominantly agricultural landscape. Limnology and Oceanography 46:970-975.

Baumann, P.C. and J.F. Kitchell. 1974. Diel patterns of distribution and feeding of bluegill (Lepomis macrochirus) in Lake Wingra, Wisconsin. Transactions of the American Fisheries Society 103:255-260.

Bennett, G.W. 1950. Experimental largemouth bass management in Illinois. Transactions of the American Fisheries Society 80:231-239.

Bennett, G.W. 1952. Pond management in Illinois. Journal of Wildlife Management 16:249-253.

Bennett, G.W. 1971. Management of lakes and ponds. Van Nostrand Reinhold, New York.

Budy, P., C. Luecke, and W.A. Wurtsbaugh. 1998. Adding nutrients to enhance the growth of endangered sockeye salmon: trophic transfer in an oligotrophic lake. Transactions of the American Fisheries Society 127:19-34.

Carlander, K.D. 1952. Farm fish pond research in Iowa. Journal of Wildlife Management 16:258-261.

Carlander, K.D. 1977. Handbook of freshwater fishery biology, volume two. Iowa State University Press, Ames, Iowa.

Clady, M.D. 1975. The effects of simulated angler harvest on biomass and production in lightly exploited populations of smallmouth and largemouth bass. Transactions of the American Fisheries Society 104:270-276.

Cramer, J.D. and G.R. Marzolf. 1970. Selective predation on zooplankton by gizzard shad. Transactions of the American Fisheries Society 99:320-322.

DeVries, D.R. and R.V. Frie. 1996. Determination of age and growth. Pages 483-512 *in* B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd Edition. American Fisheries Society, Bethesda, Maryland.

Donald, D.B. and D.J. Alger. 1986. Dynamics of unexploited and lightly exploited populations of rainbow trout (Salmo gairdneri) from coastal, montane, and subalpine lakes in western Canada. Canadian Journal of Fisheries and Aquatic Sciences 43:1733-1741.

Downing, J.A. and J. Kopaska. 2002. Ames Quarry Diagnostic Study. Iowa State University, Ames, Iowa.

Downing, J.A. and E. McCauley. 1992. The nitrogen: phosphorus relationship in lakes. Limnology and Oceanography 37:936-945.

Drenner, R.W., W.J. O'brien, and J.R. Mummert. 1982. Filter-feeding rates of gizzard shad. Transactions of the American Fisheries Society 111:210-215.

Drenner, R.W., J.R. Mummert, R. deNoyelles, Jr., and D. Kettle. 1984. Selective particle ingestion by a filter-feeding fish and its impact on phytoplankton community structure. Limnology and Oceanography 29:941-948.

Dulvy, N.K., N.V.C. Polunin, A.C. Mill, and N.A.J. Graham. 2004. Size structural change in lightly exploited coral reef fish communities: evidence for weak indirect effects. Canadian Journal of Fisheries and Aquatic Sciences 61:466-475.

Ellison, D.G. 1984. Trophic dynamics of a Nebraska black crappie and white crappie population. North American Journal of Fisheries Management 4:355-364.

Fowler, A.F. 2005a. New angler use of a midwestern waterbody with previous limited exploitation. Master's thesis. Iowa State University, Ames, Iowa.

Fowler, A.F. 2005b. Efficacy of stomach sampling in largemouth bass using the gastric lavage technique. Master's thesis. Iowa State University, Ames, Iowa.

Gablehouse, Jr., D.W. 1984a. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management. 4:273-285.

Gabelhouse, Jr., D.W. 1984b. An assessment of crappie stocks in small midwestern private impoundments. North American Journal of Fisheries Management 4:371-384.

Gabelhouse, Jr., D.W. 1987. Responses of largemouth bass and bluegills to removal of surplus largemouth bass from a Kansas pond. North American Journal of Fisheries Management 7:81-90.

Garvey, J.E. and R.A. Stein. 1998. Linking bluegill and gizzard shad prey assemblages to growth of age-0 largemouth bass in reservoirs. Transactions of the American Fisheries Society 127:70-83.

Gee, A.S. 1976. A comparison of growth rates of coarse fish in gravel-pit lakes in South-East England and of population structure in selected lakes. Ph.D.

dissertation. University of London, Dept. of Bio Sciences, Sir John Cass School of Science and Technology, City of London Polytechnic.

Goedde, L.E. and D.W. Coble. 1981. Effects of angling on a previously fished and an unfished warmwater fish community in two Wisconsin lakes. Transactions of the American Fisheries Society 110:594-603.

Haines, T.A. 1973. Effects of nutrient enrichment and a rough fish population (carp) on a game fish population (smallmouth bass). Transactions of the American Fisheries Society 102:346-354.

Havey, K.A. and D.O. Locke. 1980. Rapid exploitation of hatchery-reared brook trout by ice fisherman in a Maine Lake. Transactions of the American Fisheries Society 109:282-286.

Hill, K.R. 1983. Comparison of fish standing stocks in small Iowa lakes with and without gizzard shad. Pages 44-57 *in* Proceedings of small lakes management workshop: "pros and cons of shad". Iowa Conservation Commission and Sport Fishing Institute. Des Moines, Iowa.

Hillman, W.P. 1982. Structure and dynamics of unique bluegill populations. Master's thesis. University of Missouri, Columbia.

Jesian, R.V. 1977. The contribution of stocked trout to the sport fishery of three small Wisconsin lakes. Master's thesis. University of Wisconsin, Steven's Point, Wisconsin.

Kilambi, R.V. and R.E. Baglin, Jr. 1969. Fecundity of the gizzard shad, *Dorosoma cepedianum* (LeSueur), in Beaver and Bull Shoals reservoirs. American Midland Naturalist. 82:444-449.

Kocovsky, P.M. 1999. Dynamics and feeding ecology of the unexploited walleye population of Pymatuning sanctuary, Pennsylvania, 1997-1998. Master's Thesis, Pennsylvania State University.

Light, R.W., P.H. Adler, and D.E. Arnold. 1983. Evaluation of gastric lavage for stomach analyses. North American Journal of Fisheries Management 3:81-85.

Knowlton, M.F. and J.R. Jones. 1996. Experimental evidence of light and nutrient limitations of algal growth in a turbid Midwest reservoir. Archiv fuer Hydrobiologie 135(3):321-335.

Margenau, T.L., S.J. Gilbert, and G.R. Hatzenbeler. 2003. Angler catch and harvest of northern pike in northern Wisconsin lakes. North American Journal of Fisheries Management 23:307-312.

McInerny, M.C. and T.K. Cross. 2000. Effects of sampling time, intraspecific density, and environmental variables on electrofishing catch per effort in largemouth bass in Minnesota lakes. North American Journal of Fisheries Management 20:328-336.

Megrey, B.A. 1980. *Dorosoma cepedianum* (LeSueur), gizzard shad. P. 69 *in* D.S. Lee et al., editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Releigh.

Michaletz, P.H. 1997. Factors affecting abundance, growth, and survival of age-0 gizzard shad. Transactions of the American Fisheries Society 126:84-100.

Michaletz, P.H. 1998a. Effects on sport fish growth of spatial and temporal variation in age-0 gizzard shad availability. North American Journal of Fisheries Management 18:616-624.

Michaletz, P.H. 1998b. Population characteristics of gizzard shad in Missouri reservoirs and their relation to reservoir productivity, mean depth, and sport fish growth. North American Journal of Fisheries Management. 18:114-123.

Michaletz, P.H. 1999. Influence of reservoir productivity and juvenile density on first-year growth of gizzard shad. North American Journal of Fisheries Management 19:842-847.

Michaletz, P.H. and J.G. Dillard. 1999. A survey of catfish management in the United States and Canada. Fisheries 24:6-11.

Mittelbach, G.G. 1981. Foraging efficiency and body size: a study of optimal diet and habitat use by bluegills. Ecology 62:1370-1386.

Mittelbach, G.G. and C.W. Osenberg. 1993. Stage-structured interactions in bluegill: consequences of adult resource variation. Ecology 74:2381-2394.

Moss, J.L. and W.C. Reeves. 1983. Bluegill responses to threadfin shad elimination in a 130 acre impoundment. Pages 150-167 *in* Proceedings of small lakes management workshop: “pros and cons of shad”. Iowa Conservation Commission and Sport Fishing Institute, Des Moines Iowa.

Neal, R.A. 1963. Black and white crappie in Clear Lake, 1950-1961. Iowa State Journal of Science 37:425-455.

Nelson, J.S. 1994. Fishes of the World. John Wiley and Sons, Inc. New York, New York.

Neumann, R.M. and B.R. Murphy. 1991. Evaluation of the relative weight (Wr) index for assessment of white crappie and black crappie populations. North American Journal of Fisheries Management 11:543-555.

Noble, R.L. 1981. Management of forage fishes in impoundments of the southern United States. Transactions of the American Fisheries Society 110:738-750.

O'Brien, W.J., B. Loveless, and D. Wright. 1984. Feeding ecology of young white crappie in a Kansas reservoir. North American Journal of Fisheries Management 4:341-349.

Paukert, C.P. and D.W. Willis. 2001. Comparison of exploited and unexploited yellow perch *Perca flavenscens* (Mitchill) populations in Nebraska sandhill lakes. Fisheries Management and Ecology 8:533-542

Pflieger, W.L. 1997. The Fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Sammons, S.M., D.A. Isermann, and P.W. Bettoli. 2002. Variation in population characteristics and gear selection between black and white crappies in Tennessee reservoirs: potential effects on management decisions. North American Journal of Fisheries Management 22:863-869.

Schnabel, Z.E. 1938. The estimation of the total fish population of a lake. American Mathematical Monographs 45:348-368.

Schneider, J.C. 1971. Characteristics of a population of warmwater fish in a southern Michigan lake. Michigan Department of Natural Resources Research and Development Report 236, Ann Arbor, Michigan.

Spier, T.W. and R.C. Heidinger. 2002. Effect of turbidity on growth of black crappie and white crappie. North American Journal of Fisheries Management 22:1438-1441.

Stone, C. and J. Lott. 2002. Use of a minimum length limit to manage walleyes in Lake Francis Case, South Dakota. North American Journal of Fisheries Management 22:975-984.

Swingle, H.S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Alabama Polytechnic Institute, Agricultural Experiment Station Bulletin 274, Auburn.

Swingle, H.S. 1956. Appraisal of methods of fish population study, part 4: determination of balance in farm fish ponds. Transactions of the North American Wildlife Conference 21:298-322.

Van den Avyle, M.J. and R.S. Hayward. 1999. Dynamics of exploited fish populations. Pages 127-166 *in* C.C. Kohler and W.A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.

Wade, J.C. and E.O. Heady. 1976. A national model of sediment and water quality: various impacts on American agriculture. The Center for Agricultural and Rural Development, Card Report 67. Ames, Iowa.

Water quality intro.

Wege, G.J. and R.O. Anderson. 1978. Relative weight (W_r): a new index of condition for largemouth bass. Pages 79-91 *in* G.D. Novinger and J.G. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division, Special Publication 5, Bethesda, Maryland.

Whitcomb, S.K. 2000. Watershed effects on the aquatic communities of Iowa ponds. Master's thesis. Iowa State University, Ames, Iowa.

Whittier, T.R., D.P. Larsen, S.A. Peterson, and T.M. Kincaid. 2002. A comparison of impoundments and natural drainage lakes in the northeast USA. Hydrobiologia 470:157-171.

CHAPTER 3. NEW ANGLER USE OF A MIDWESTERN FISHERY WITH PREVIOUS LIMITED EXPLOITATION

A paper to be submitted to the North American Journal of Fisheries Management

Andy L. Fowler and Joseph E. Morris

Abstract

Ada Hayden Heritage Park, Ames, Iowa is a public gravel quarry fishery newly opened to exploitation on July 1, 2004. An expandable creel survey was conducted from July 1, 2004 to October 14, 2004; 220 angler hrs/ha were observed in July 2004 at the opening of the fishery. This rate fell rapidly in proceeding months. There were significant decreases in crappie, channel catfish, and yellow perch average weights caught over time. Angler catch per unit effort (CPUE) did not significantly change as angling progressed for any species; however, mean trip length did significantly decrease throughout the survey.

Introduction

Ada Hayden Heritage Park (AHHP) in Ames, Iowa, was bought in 2001 by the city of Ames to preserve this high quality water as a reserve water source for the municipality. Due to past private ownership, the quarry has never undergone normal public exploitation.

Unexploited fisheries in Iowa and the midwest are very rare as most public areas are already being exploited. Few studies have looked at unexploited populations in or around the Midwest (Reed and Rabeni 1989; Paukert and Willis 2001). Unexploited populations typically are characterized as having large populations of older, larger fish (Goedde and Coble 1981). However, Goedde and Coble (1981) noted that length and age frequency distributions shifted toward smaller sizes and younger ages as angler pressure began. Schneider (1971) described a “carnival atmosphere” of boat ramp lines and the presence of massive numbers of new anglers as new angling pressure began on Mill Lake in Michigan. He also indicated small amounts of fishing can make relatively large reductions in a “virgin”, unexploited fish population. City of Ames Parks and Recreation Department personnel fully expected the opening of AHHP to resemble a “carnival atmosphere” and implemented management regulations accordingly to limit possibilities of overexploitation.

AHHP was opened for public use on July 1, 2004. Special city regulations that apply to this fishery include: a catch and release only regulation on bass, daily bag limits of 5 and 10 crappie and bluegill respectively, outboard motors are banned on any boat entering the water, and fishing excluded spawning zones during the spring. All other regulations are pursuant to the standards set down by the Iowa Department of Natural Resources.

The objectives of this project are to (1) estimate angler use through an expandable angler count, (2) estimate harvest through expandable creel surveys, (3) determine significant changes in angler catch per unit effort, and (4) determine if significant changes in fish size occur during exploitation.

Methods

Site description

This study was conducted at Ada Hayden Heritage Park, Ames, Iowa; the waterbody consists of a north and south basin (16-ha and 34-ha respectively). This former quarry site is characterized by mesotrophic nutrient enrichment, little littoral zone, and high water clarity as described by Downing and Kopaska (2002). The site has a main parking lot on the north side of the park where most anglers enter. However, access is available at many points along an extensive trail system surrounding the perimeter. The park's southern boundary is urbanized, adding further access for individuals.

Methodology

The following methods are modified from (IA DNR 1984; Pollock et al. 1994). An expandable creel survey was conducted. All possible angler days between July 1, 2004 and October 15, 2004 were defined as either weekdays or weekend days. The park officially opens up each day at 6:00 am and closes at 10:30 pm. Each day was divided into three 5.5-hour periods and referred to as A, B, or C periods with the 'A' period in the morning and the 'C' period at night. Nine weekday periods were sampled in July, 6 weekdays in August, 4 weekdays in September, and 3 weekdays in October. Four weekend periods were sampled every month except for 3 periods in October. Initial fishing pressure was estimated, starting on July 1 by consecutively sampling 6 days of random periods. All possible days and periods were chosen randomly afterwards. Reported July estimates incorporate consecutively sampled days.

All anglers were counted once every 2 hours starting at the beginning of the shift and then also at the end of the shift. Angler surveys consisted of a variety of questions that were recorded. The questions included the start time of fishing that day, city originated from, and through what medium the angler learned about the opening of this new park. The number of fish in the angler's creel was recorded to species and a total weight of each species was recorded. Black *Pomoxis nigromaculatus* and white *Pomoxis annularis* crappies are referred to jointly as crappie.

Data analysis

Creel parameters were estimated using creel formulas in (IA DNR 1984). Mean trip length (MTL) calculation was an exception. MTL was calculated based on completed trips. However, when completed trips (trips where the angler was at least interviewed at the end of their fishing day) were not available, the averages of incomplete trips were used due to the low number of period sampling times in this project.

Statistical analysis

A generalized linear mixed model was used to ascertain significant differences in catch per unit effort and average angler weight of species across the breadth of the creel survey. Date was used as a continuous variable to account for the random effects of one day to the next. Catch per unit effort was $\log_e$ transformed due to expanding residuals. All p values greater than or equal to 0.1 were considered significant.

Results

Angler estimates

Angling hours per hectare dropped off sharply after the start of exploitation began (Figure 3.10). July started out with a total of 75.8 total boat angler hrs/ha throughout the period. Shore anglers totaled 144.7 angler hrs/ha in July; this equates to a sum of 220 total angling hrs/ha in July. There were 4,790 total estimated anglers in July, followed by 1,991 anglers in August (Figure 3.11). Mean trip length significantly decreased (Figure 3.12) across sampling dates ($p = 0.029$) and boat anglers spent significantly longer fishing than shore anglers ($p < 0.001$). Period A mean trip length was also significantly less than period B ($p = 0.004$) and C ($p = 0.052$). Figures 3.13 and 3.14 detail the quantitative and gravimetric estimated harvest respectively for AHHP. Most harvest was in crappie species, containing 80% of the total estimated biomass harvested (Figure 3.14). Boat angler harvest estimates were typically more than shore angler harvest estimates. Sixty-seven percent of all anglers interviewed were from the Ames area (Figure 3.15) and 90% of all anglers interviewed were less than 40 km from home.

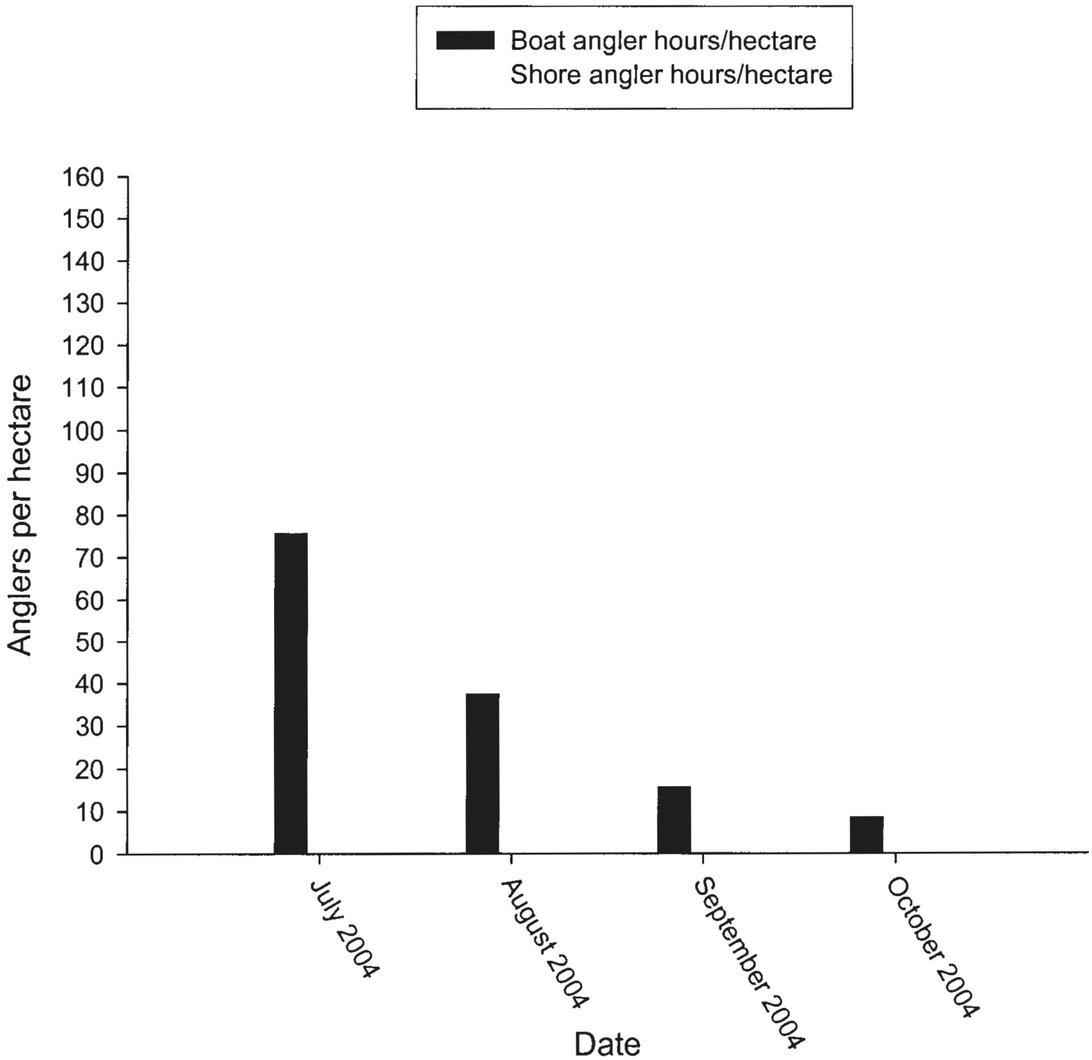


Figure 3.10. Estimate of boat and shore angling hours per hectare per month at Ada Hayden Heritage Park, Ames, Iowa, fall 2004. New exploitation began July 1, 2004.

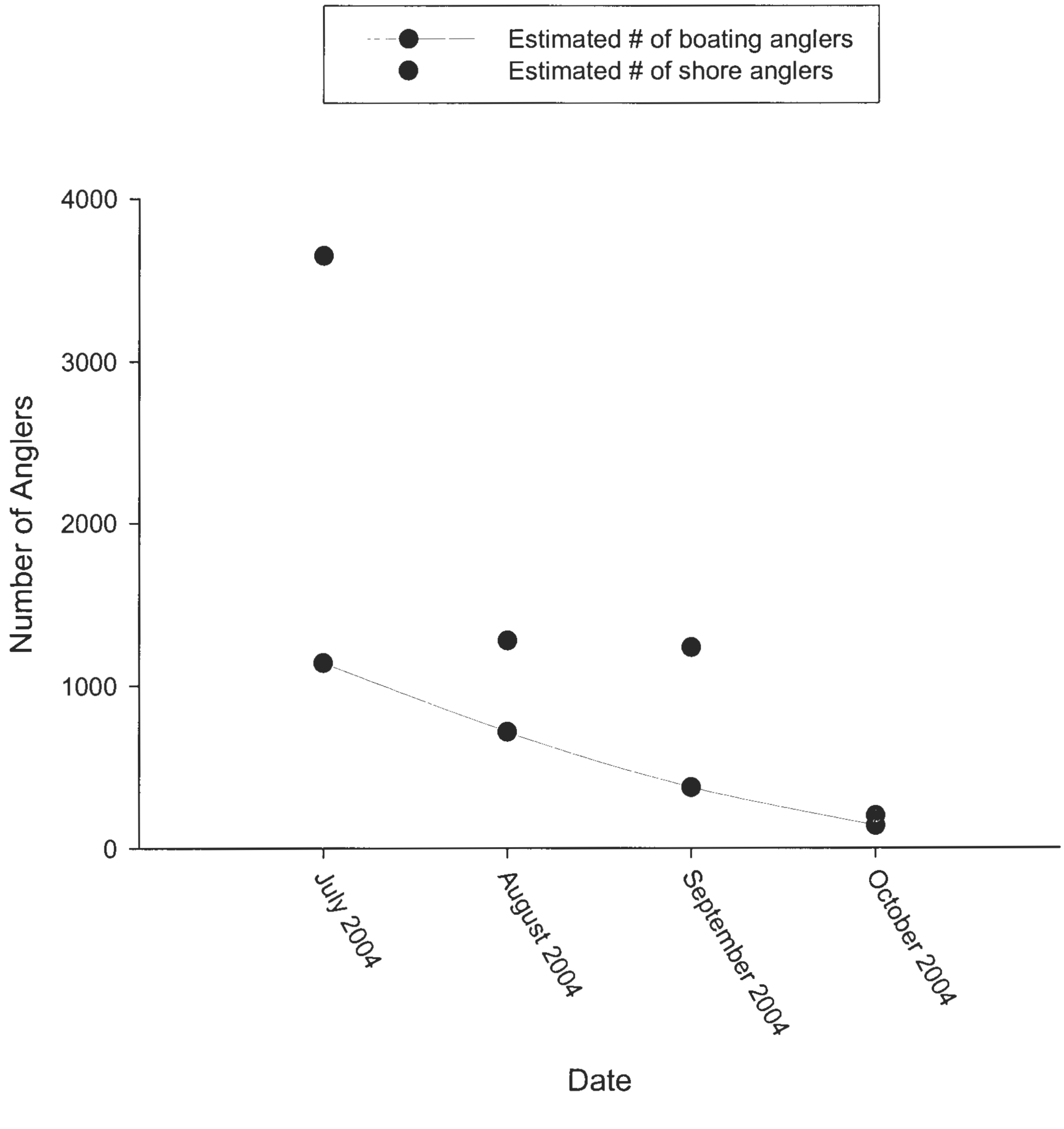


Figure 3.11. Total estimated number of anglers at Ada Hayden Heritage Park, Ames, Iowa, fall 2004. New exploitation began July 1, 2004.

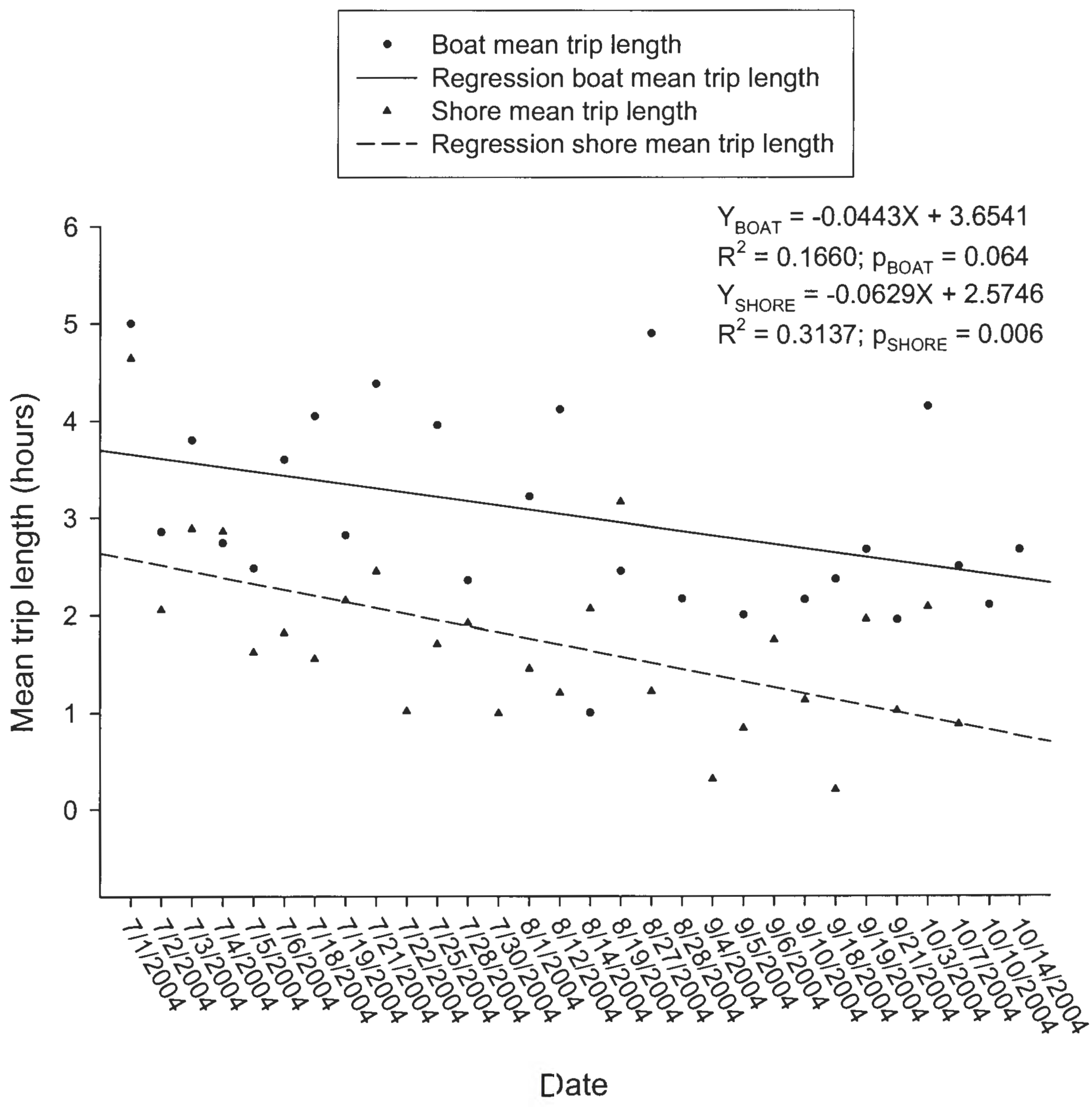
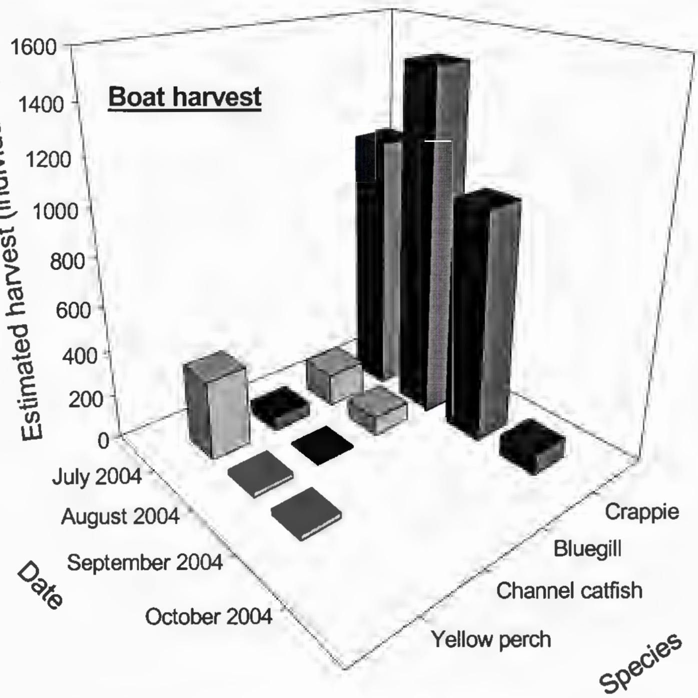


Figure 3.12. Mean trip length (hours) of interviewed anglers at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.



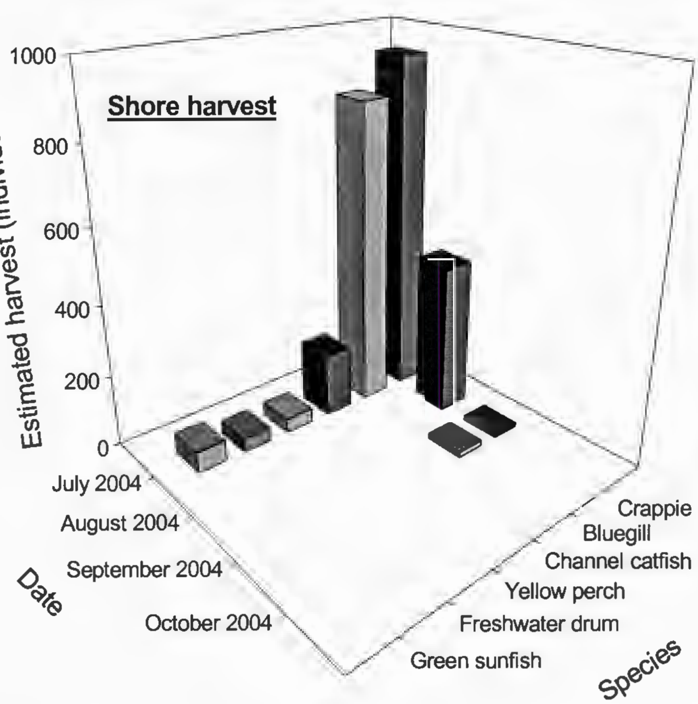


Figure 3.13. Estimated numerical harvest for boat and shore anglers at Ada Hayden Heritage Park, Ames, Iowa, fall 2004. New exploitation began July 1, 2004.

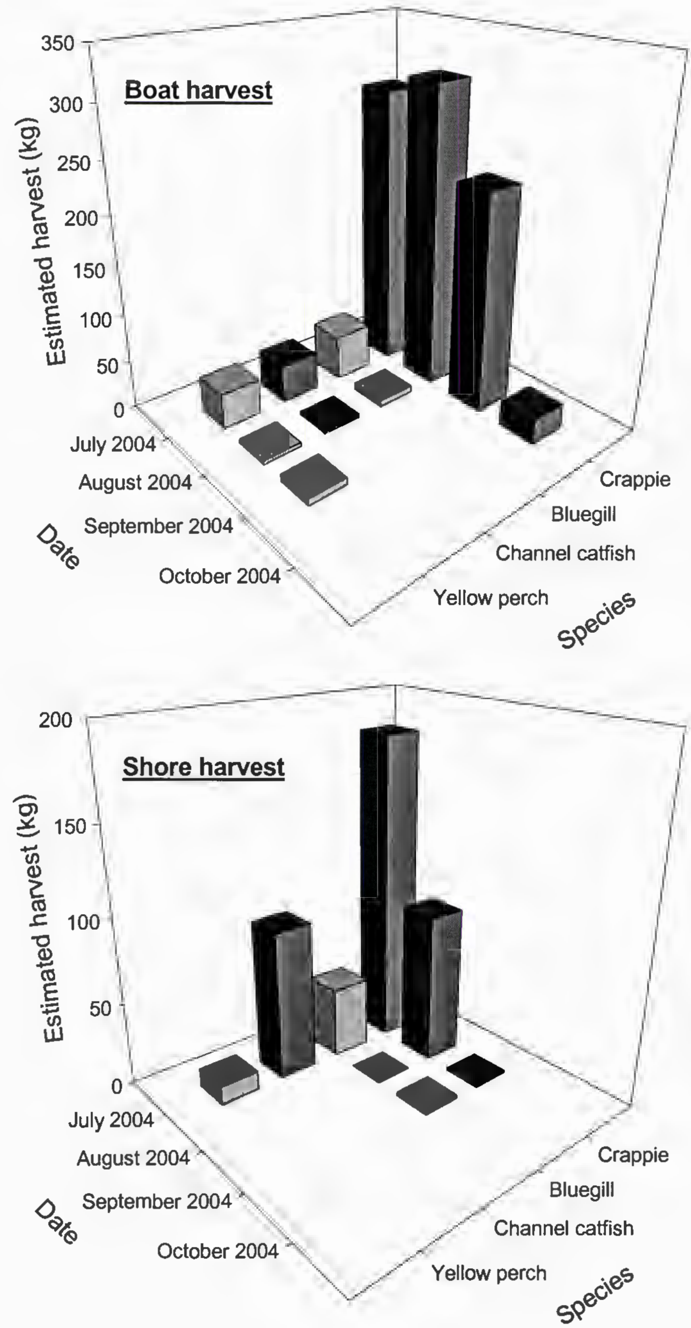


Figure 3.14. Estimated gravimetric harvest for boat and shore anglers at Ada Hayden Heritage Park, Ames, Iowa, fall 2004. New exploitation began July 1, 2004.

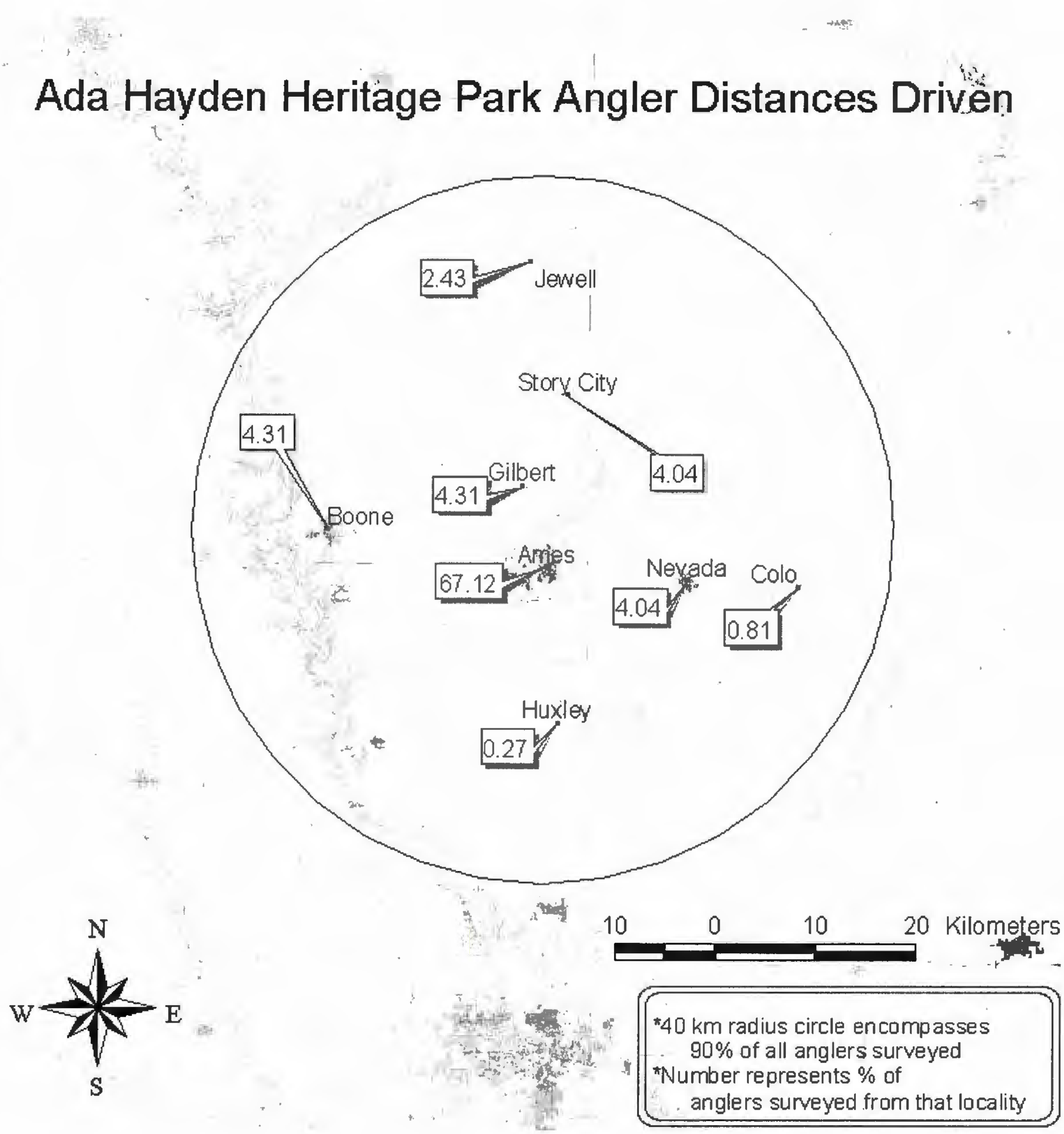


Figure 3.15. Percentage of interviewed anglers from area municipalities at Ada Hayden Heritage Park, Ames, Iowa, fall 2004.

Average weight of fish species

The average boat angler caught significantly heavier crappie than shore anglers ($p = 0.037$) (Figure 3.16). Both types of anglers had a significant decline in the weight of the average crappie they caught over time ($p = 0.001$). There were no significant differences in bluegill average weights over time ($p = 0.9411$) or between angler types ($p = 0.601$) (Figure 3.17). The average weight of angler caught channel catfish (Figure 3.18) did significantly decline over time ($p = 0.006$) despite the insignificant p-values reported for individual regression lines in Figure 3.18. Weekend ($p = 0.018$) and boat anglers ($p = 0.080$) also caught significantly heavier channel catfish than weekday and shore anglers. The average angler who caught yellow perch also saw a significant decline in mean weight over time ($p = 0.033$) (Figure 3.19).

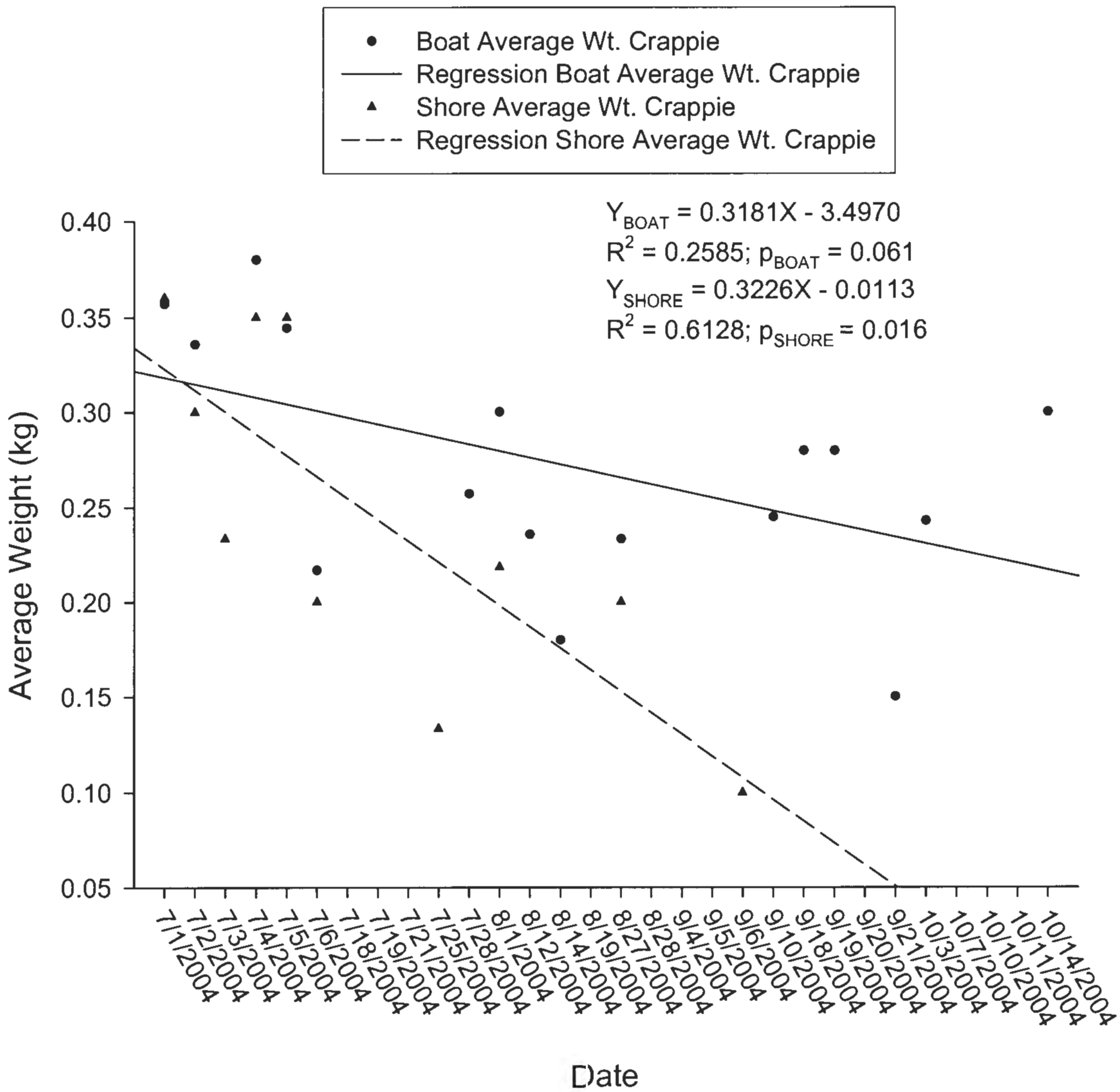


Figure 3.16. Crappie average weight (kg) caught at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

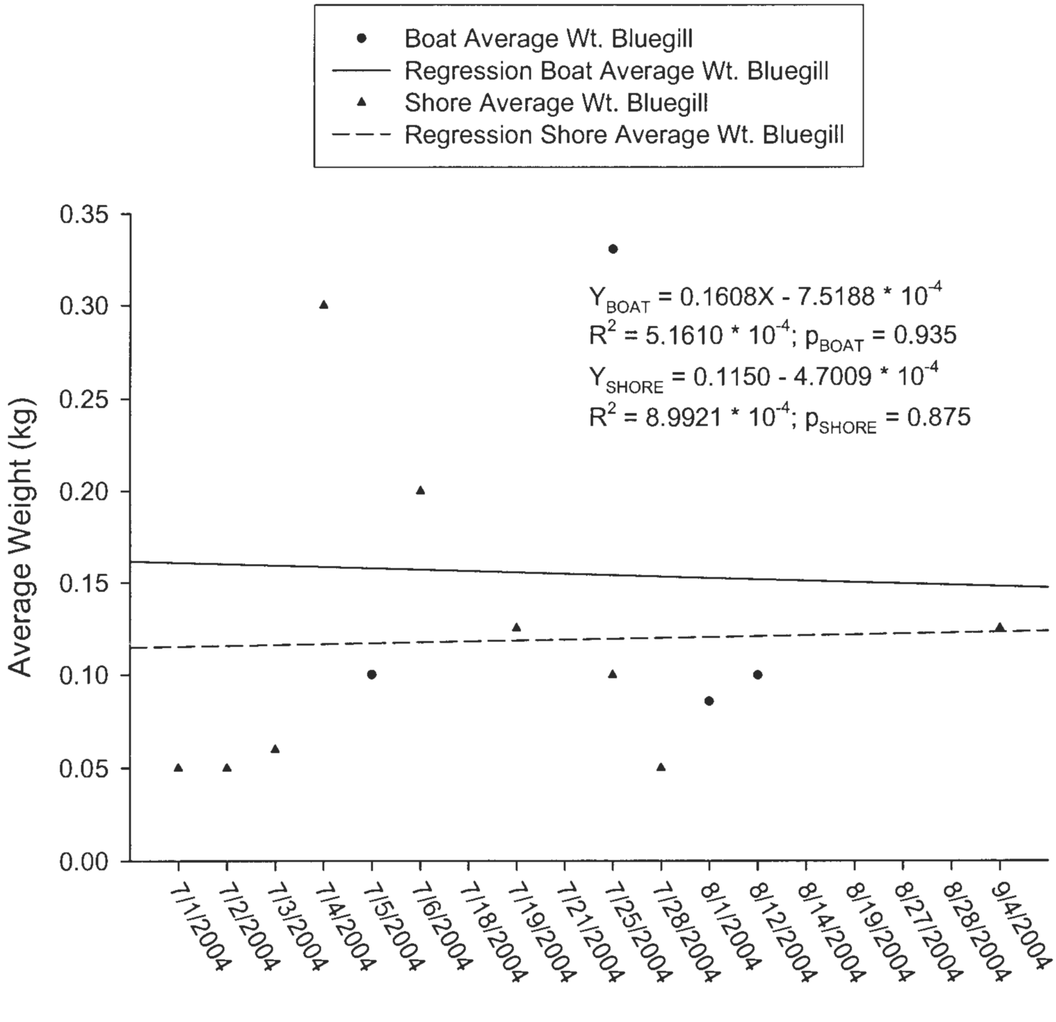


Figure 3.17. Bluegill average weight (kg) caught at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

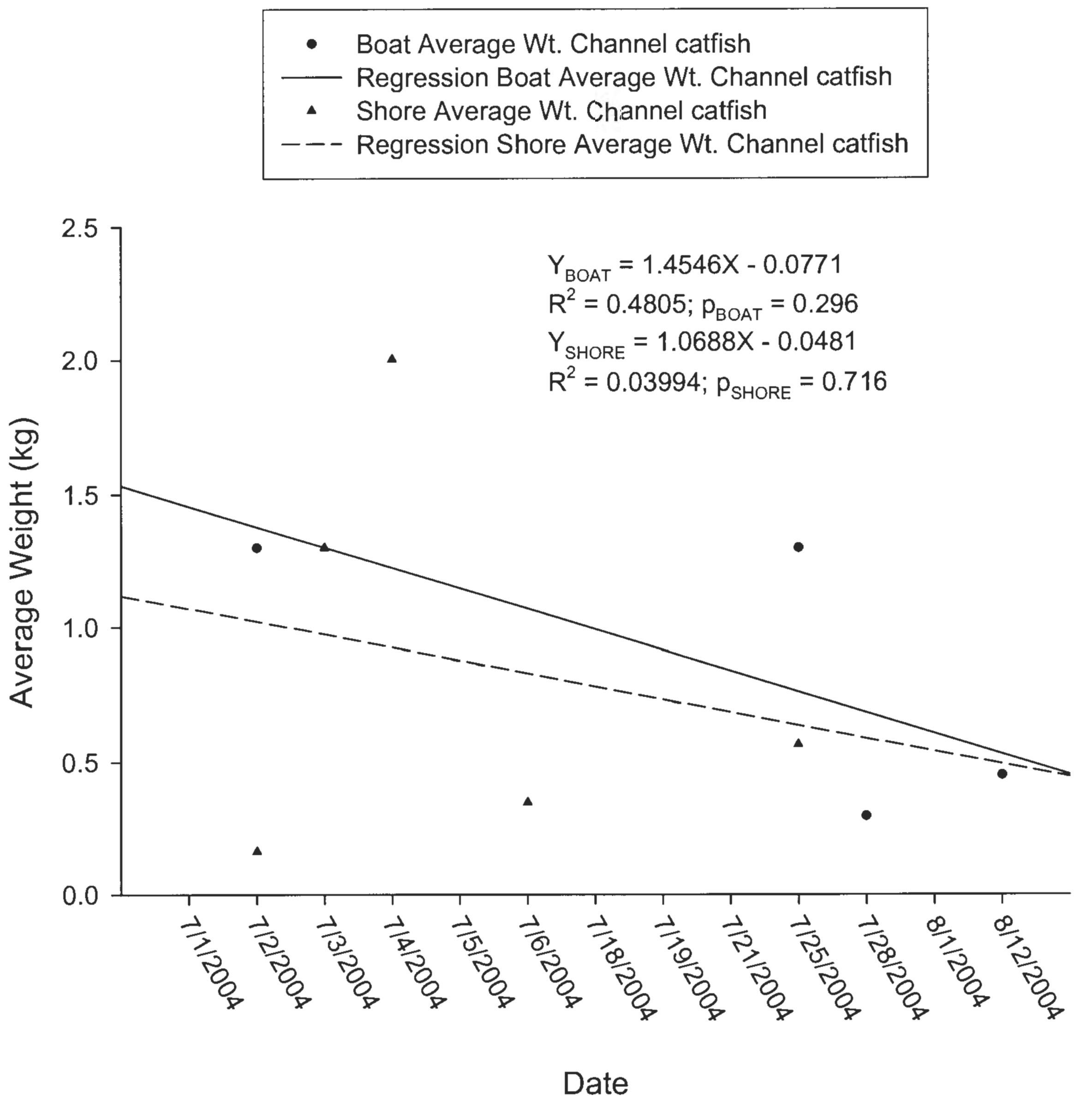


Figure 3.18. Channel catfish average weight (kg) caught at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

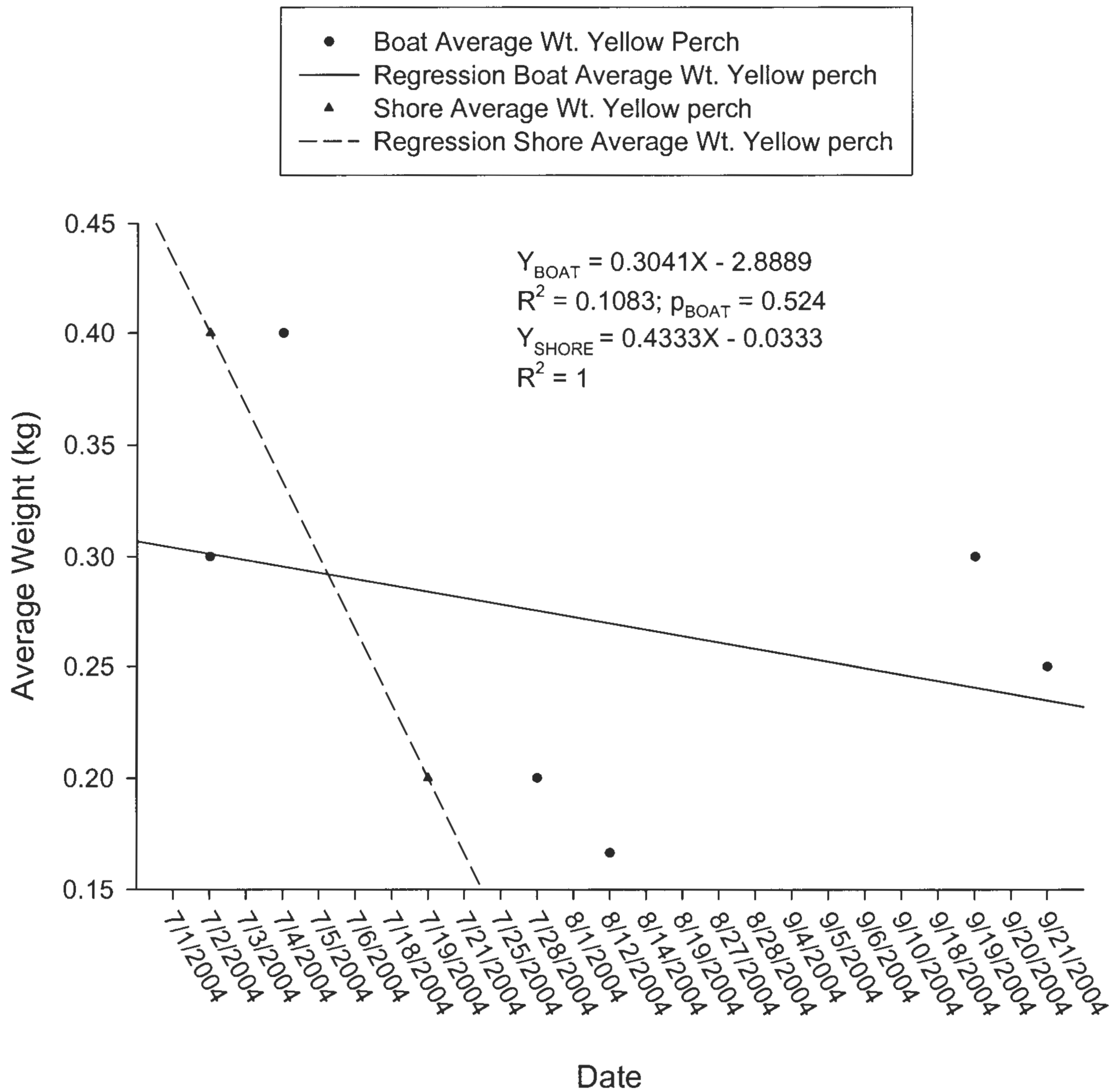


Figure 3.19. Yellow perch average weight (kg) caught at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

Angler catch per unit effort (CPUE)

There was no significant change in angler CPUE over time for any species except channel catfish CPUE had a significant increase (p = 0.081) (Figure 3.22). Boat anglers had a significantly higher CPUE for crappie than did shore anglers (p = 0.002) (Figure 3.20). Bluegill CPUE was not significantly different between boat or shore anglers; however, weekend anglers had a significantly higher CPUE than weekday anglers (p = 0.083) (Figure 3.21). There was no significant difference in the rates of CPUE between boat and shore anglers of channel catfish (p = 0.896) (Figure 3.22). Boat anglers had a significantly higher yellow perch CPUE than shore anglers (Figure 3.23) (p = 0.006); however, the shore estimate is based on only two observations.

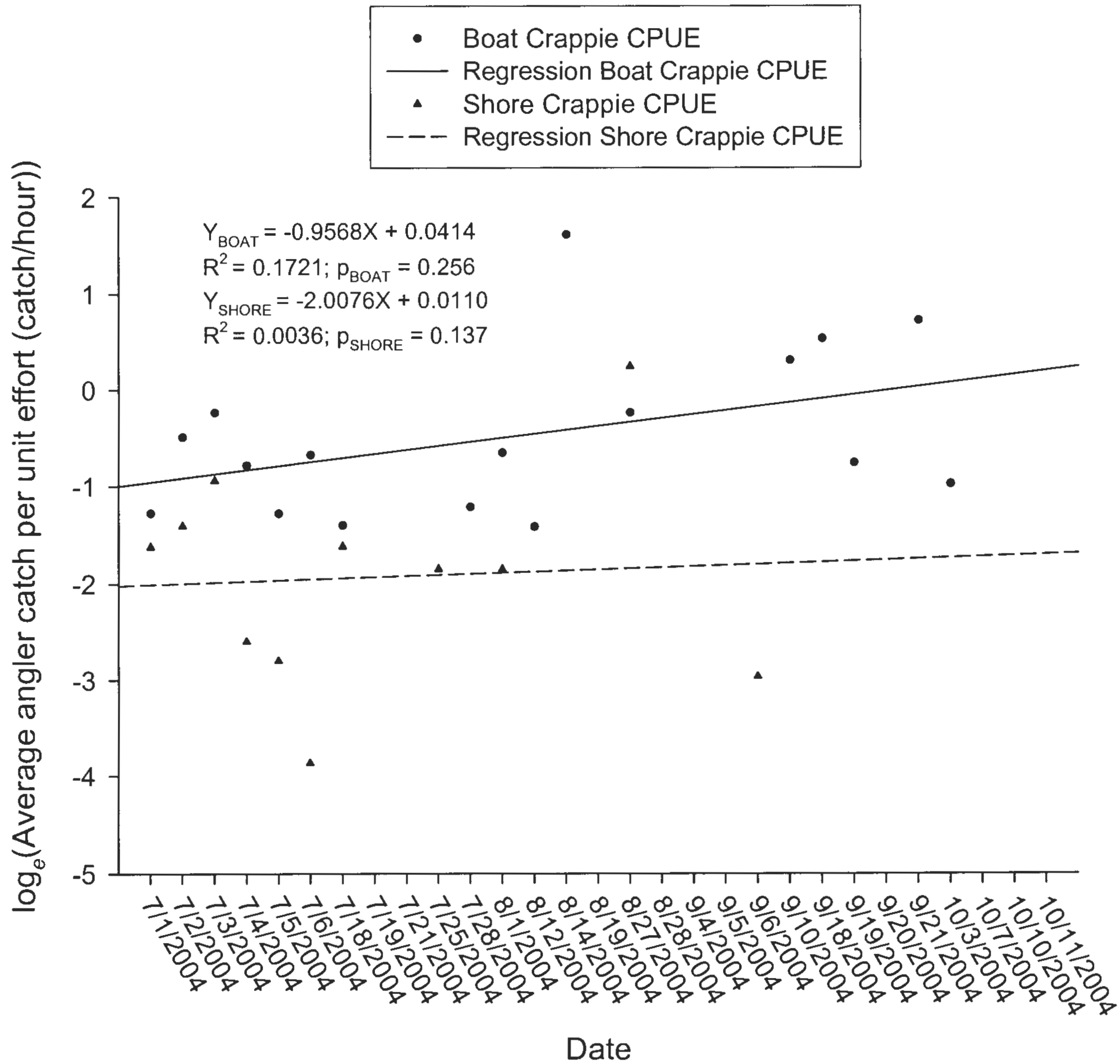


Figure 3.20. Angler crappie catch per unit effort (CPUE) at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

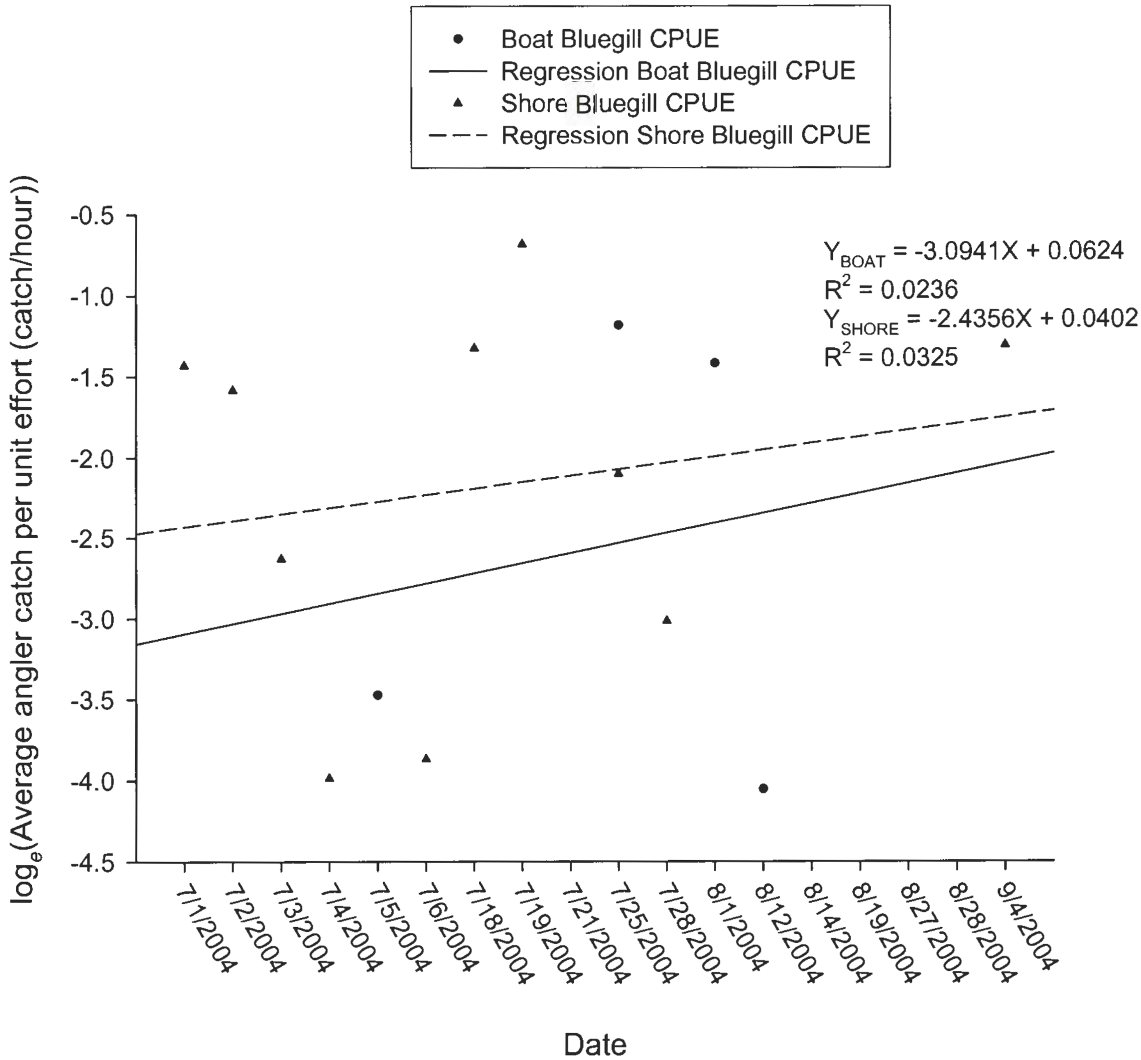


Figure 3.21. Angler bluegill catch per unit effort (CPUE) at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

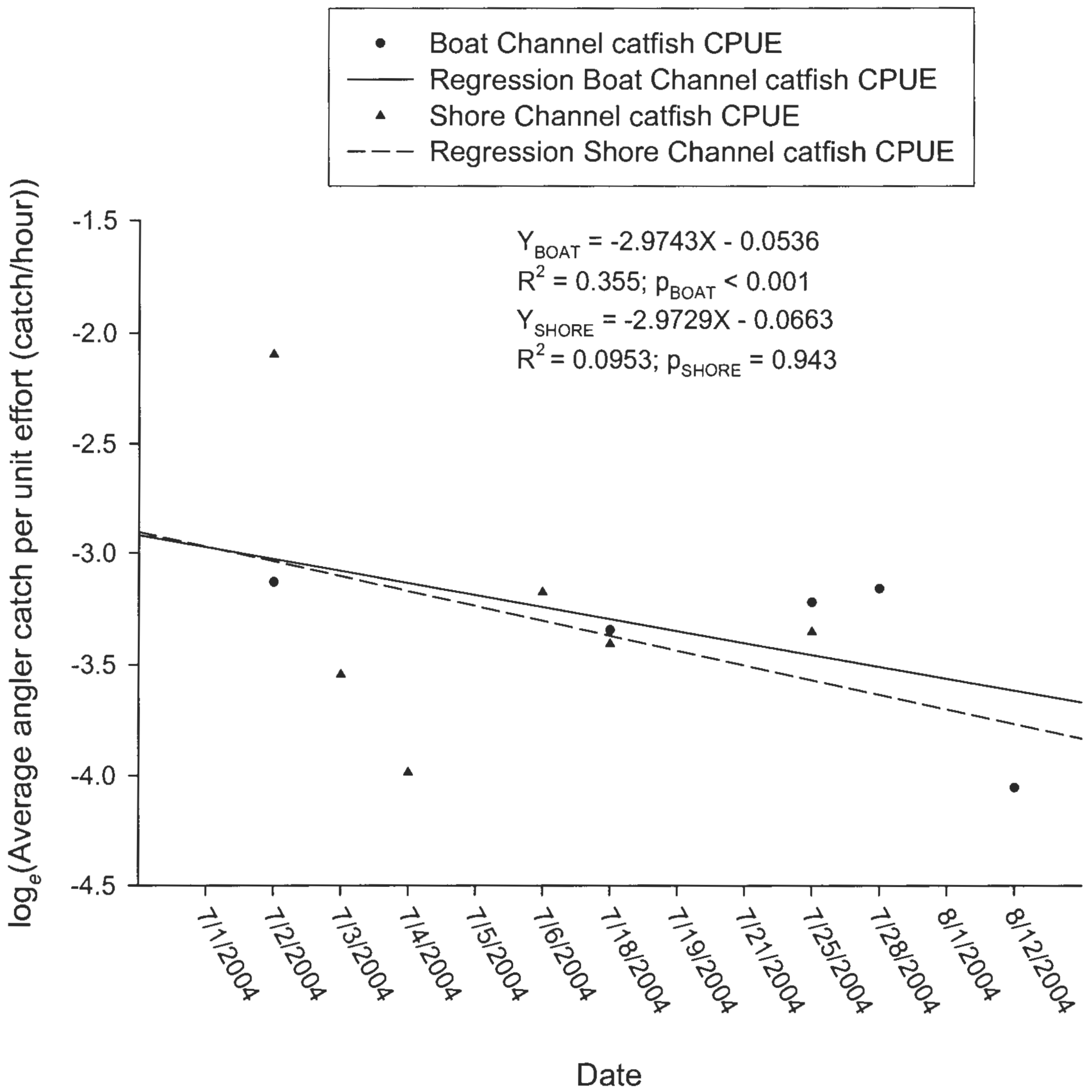


Figure 3.22. Angler channel catfish catch per unit effort at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

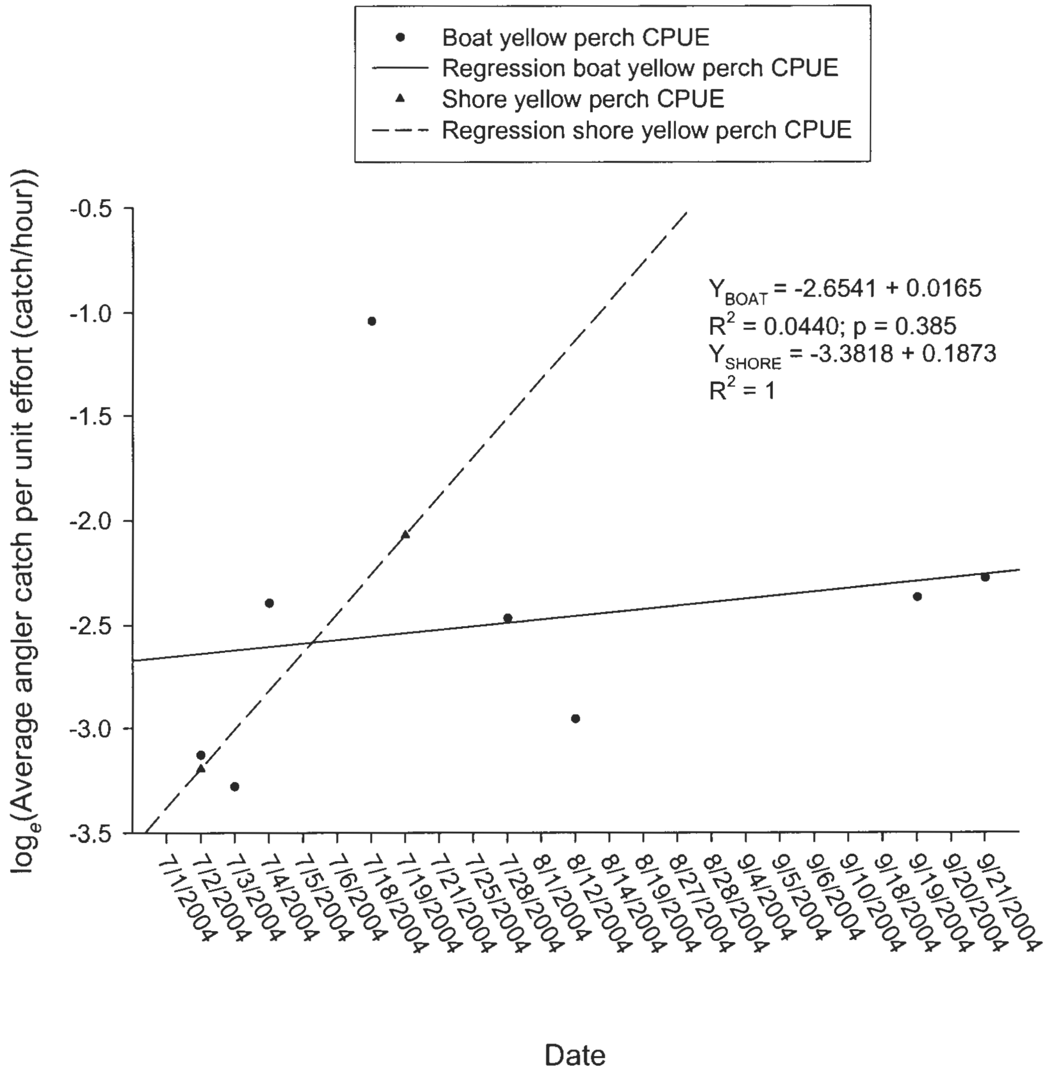


Figure 3.23. Angler yellow perch catch per unit effort at Ada Hayden Heritage Park, Ames, Iowa, July 2004 to October 2004. New exploitation began July 1, 2004.

Discussion

Angler usage

Initial exploitation of AHHP was 220.5 total angling hrs/ha in the month of July (Figure 3.10). Goedde and Coble (1981) saw 231 total angling hours/hectare in May on 4.7-ha Mid Lake in Wisconsin upon its public opening; 3 years later this had declined to 62 angling hrs/ha in May of 1979. Total angling effort in Ada Hayden had already dropped to 60.2 angling hrs/ha by August 2004 (Figure 3.10). Thus, angler usage at Ada Hayden not only decreased sharply, but it decreased to post-3 year levels in only a month when compared to a waterbody with a similar situation.

Schneider (1971) noted an exploitation of 15.8 angling hrs/ha in only the first 3 days of angling in August 1969, on Mill Lake in Michigan. At this rate, total angling hours in Mill Lake for August 1969 would be equal to 163.1 hrs/ha. Angling effort at AHHP in July is comparable to most other newly exploited fisheries. However, in only 1 month, angler usage at AHHP dropped to very low levels. Angler mean trip length (Figure 3.12) also saw significant declines, adding to an already decreasing fishing pressure.

The AHHP fishery also did not recruit anglers from a large area as expected by city of Ames parks and recreation department personnel; 67% of all anglers interviewed during the creel survey were from Ames. Ninety percent of the total anglers interviewed were within 40 km of Ames (Figure 3.14). We speculate that the stringent harvest and boating regulations by the city may have decreased the number of anglers desiring to drive to the new fishery.

Fishery impacts

Significant declines in average weights of creeled crappie, channel catfish, and yellow perch indicate that sufficient fishing pressure was present to remove some of the larger individuals. However, Fowler (2005) saw no detectable changes related to exploitation in mean PSD values or relative weights of almost all species sampled from electro-fishing surveys conducted at AHHP during the same study period. Thus, while creeled fish may indicate a change, the change has been slight enough to not be detected in routine fisheries surveys. The fishery at AHHP has most likely not been impacted greatly by angler exploitation.

Boating anglers at AHHP had significantly higher CPUE for crappie and yellow perch compared to shore anglers. This is not surprising, as both species are a more pelagic species (O'Brien et al. 1984; Bergman 1988). Also, there is little habitat near shore to attract crappie or yellow perch and consequently make them vulnerable to shore anglers. Thus, crappie and yellow perch would be more easily caught by boat anglers.

Fowler (2005) conducted population estimates on AHHP bluegill. Using that estimate and our angler harvest estimate, we calculated a 13% exploitation rate for bluegill ≥ 100 mm, July through October. This is much less than bluegill exploitation of 27% recorded by Coble (1988) and much less than recorded at the opening of Mid Lake, Wisconsin; first month exploitation there for bluegill was 35% (Goedde and Coble 1981). In this regard, AHHP has not undergone extreme exploitation. In contrast, crappie biomass harvest at roughly 80% of the total estimated fish biomass harvested was much more than bluegill harvest. We do not know the exact exploitation level on crappie populations because population estimates were not able to be completed on either crappie species (Fowler 2005). However, low exploitation of bluegills, low overall angler use rates, and no significant changes in catch per unit effort found by Fowler (2005) in crappie species by electro-fishing surveys at AHHP, lead us to believe the exploitation rate of crappie has not significantly affected the fishery. Angling effort has dropped so quickly that species have most likely not been affected.

Ice fishing anglers can rapidly exploit a fishery (Havey and Locke 1980) and have been shown to retain more of the caught fish than open water anglers (Margenau et al. 2003). The ice fishing season of 2004 to 2005 and future exploitation in general may lead to a general decline in the crappie fishery at AHHP.

A study of new exploitation by Goedde and Coble (1981) discussed significant changes of new exploitation over a period of 6 years. Our study was initially proposed at a time when exploitation was scheduled to begin in November 2003. The presently studied 4-month exploitation period at AHHP has probably not been enough time to detect changes. With additional post-exploitation time, significant changes may yet occur at AHHP.

Conclusion

While AHHP did experience a high rate of angler use at first and creeled species did exhibit declines in average weight, the fishery remains relatively unimpacted due to a sharply decreasing angler use rate of AHHP and low angler recruitment from neighboring municipalities. However, this study period consists of only 4 months, and does not include an ice fishing season. Fishery degradation may yet occur. Future fishery and creel surveys should be implemented to address any significant changes yet to appear.

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We would like to thank all the technicians and graduate students who helped make this project possible. We would also like to thank Dick McWilliams and Joe Larscheid of the Iowa Department of Natural Resources and Phillip Bettoli of the Tennessee Cooperative Fishery Research Unit for their advice throughout this project. Also, we would like to thank the city of Ames for their wonderful cooperation in making this project possible on Ada Hayden Heritage Park.

Literature Cited

Bergman, E. 1988. Foraging abilities and niche breadths of two percids, *Perca fluviatilis* and *Gymnocephalus cernua*, under different environmental conditions. Journal of Animal Ecology 57:443-453.

Coble, D.W. 1988. Effects of angling on bluegill populations: management implications. North American Journal of Fisheries Management 8:277-283.

Downing, J.A. and J. Kopaska. 2002. Ames Quarry Diagnostic Study. Iowa State University, Ames, Iowa.

Fowler, A. 2005. Characterization of a midwestern fishery with limited exploitation. M.S. Thesis. Iowa State University, Ames, Iowa.

Goedde, L.E. and D.W. Coble. 1981. Effects of angling on a previously fished and an unfished warmwater fish community in two Wisconsin lakes. Transactions of the American Fisheries Society 110:594-603.

Havey, K.A. and D.O. Locke. 1980. Rapid exploitation of hatchery-reared brook trout by ice fisherman in a Maine Lake. Transactions of the American Fisheries Society 109:282-286.

IA DNR (Iowa Department of Natural Resources). 1984. Annual Performance Report, Research Segment. Natural Lakes Investigations, Winterkill Lakes, Sport fish Harvest, Project No. F-95-R.

Margenau, T.L., S.J. Gilbert, and G.R. Hatzenbeler. 2003. Angler catch and harvest of northern pike in northern Wisconsin lakes. North American Journal of Fisheries Management 23:307-312.

O'Brien, W.J., B. Loveless, and D. Wright. 1984. Feeding ecology of young white crappie in a Kansas reservoir. North American Journal of Fisheries Management 4:341-349.

Paukert, C.P. and D.W. Willis. 2001. Comparison of exploited and unexploited yellow perch *Perca flavenscens* (Mitchill) populations in Nebraska sandhill lakes. Fisheries Management and Ecology 8:533-542

Pollock, K.H., C.M Jones, and T.L. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publication 25, Bethesda, Maryland.

Reed, M.S. and C.F. Rabeni. 1989. Characteristics of an unexploited smallmouth bass population in a Missouri Ozark stream. North American Journal of Fisheries Management 9:420-426.

Schneider, J.C. 1971. Angling on Mill Lake, Michigan, after a five-year closed season. Michigan Academician 5:349-355.

CHAPTER 4. EFFICACY OF STOMACH SAMPLING IN LARGEMOUTH BASS USING THE GASTRIC LAVAGE TECHNIQUE

A paper to be submitted to the North American Journal of Fisheries Management

Andy L. Fowler and Joseph E. Morris

Abstract

The gastric lavage technique for the removal of stomach contents in largemouth bass was studied for efficiency and mortality at Ada Hayden Heritage Park, Ames, Iowa. The technique was 100% effective at removing the stomach contents in largemouth bass and was shown to have zero mortality during a roughly 1-week observational period.

Introduction

Many different stomach sampling techniques exist in fisheries science. Popular methods include stomach pumps (Hayward and Bushman 1994), inserting tubes into the stomach to envelope contents (Pope et al. 2001), and the gastric lavage technique (Seaburg 1957). The gastric lavage technique is a common non-lethal method for sampling the stomach contents of fish (Brosse et al. 2002; Light et al. 1983; Cochran and Adelman 1982). Brosse et al. (2002) found the average prey recovery rate from farmed Siberian sturgeons *Acipenser baeri* to be 67.5% with no mortality. Light et al. (1983) researched the efficiency of this gastric lavage technique on brook trout *Salvelinus fontinalis* and slimy sculpins *Cottus cognatus*, and found it to be 98% and 100% effective, respectively, at removing all gut contents from sampled fish. No mortality was observed over the 3-week post-lavage period.

To date there is little research available on the efficiency or effects of mortality upon largemouth bass *Micropterus salmoides* by the use of the gastric lavage stomach sampling technique (Hakala and Johnson 2004). The objectives of this project are to (1) evaluate the efficiency of the gastric lavage technique in largemouth bass and (2) determine if any short term mortality is incurred using this technique.

Methods

This observational study was incorporated into a concurrent study by Fowler (2005) at Ada Hayden Heritage Park (AHHP) that collected largemouth bass stomach samples. Largemouth bass were placed in a specially designed holding trough fitted with a 500-um mesh screened collection bottle (Figure 4.10). The stomachs contents were expelled by the gastric lavage technique (Light et al. 1983) and collected into the collection bottle using a 12-volt, 600-gph water pump (Simer Blue Water Pump, Model No. BW85P, Delavan, Wisconsin) and flexible plastic tubing (10 mm, outside diameter, 6 mm, inside diameter). All water used was lake water, filtered through 500-um mesh to prevent contamination of the forage samples. Each fish typically required < 30 seconds to complete the technique. Stomach contents samples were then stored in buffered 10% formalin. Fish were tagged using opercular metal strap and Floy™ tags for later mortality identification. The utmost care was given to the fish throughout the entire process to prevent injury. Most fish were released after recovery. Fish not released, were selected for observation in a holding net or sacrificed to confirm if the stomachs were empty.

Mortality from the gastric lavage technique was estimated by observation in a holding net located in roughly 4 m of water. The holding net consisted of a 1.22-m^3, 6-mm mesh, green coated net (Miller Net and Twine, Memphis, Tennessee). Floats were installed to keep the net on the surface for ease of observation, weights were installed on the bottom of the net to keep the net from collapsing upon fish, and a screen was added on the surface to provide shade and prevent escape. From October 29, 2003 to November 4, 2003, 10 stomach sampled largemouth bass were held in the holding net, 10 additional largemouth bass were used as a control. Length ranged from 129-365 mm. On April 22, 2004 to April 27, 2004, six stomach sampled largemouth bass were held for observation in the holding net, 4 additional largemouth bass were used as a control. Length ranged from 180-411 mm. Fish were observed for mortalities each day. Daily oxygen and temperature readings were recorded.

Evacuation effectiveness was estimated for the gastric lavage technique by sacrificing fish post-lavage. The pericardial cavity was slit and fish were individually preserved in buffered 10% formalin in the field. In the lab, stomach contents were removed and gut contents examined. Sacrificed fish were marked as either full or not fully evacuated. On April 27, 2004, four largemouth bass were sacrificed. They ranged in lengths from 260-348 mm. On June 17, 2004, 1 largemouth bass at 277 mm was sacrificed. On October 25, 2004, five largemouth bass were sacrificed. They ranged in lengths from 280-355 mm. A detailed description of all fish involved is shown in Table 4.10.

Figure 4.10. Gastric lavage stomach sampling trough with 500-um filtered collection bottle used at Ada Hayden Heritage Park, Ames, Iowa, 2003-2004.

Results

No mortalities were observed during either observation trial. All sacrificed largemouth bass had no remaining food items in their stomachs (Table 4.10).

Table 4.10. Stomach evaluation before and after the gastric lavage technique on largemouth bass in Ada Hayden Heritage Park, Ames, Iowa. E=Empty, NE=Not Empty.

Fish #	Date	Length (mm)	Weight (g)	Pre-Lavage	Post-Lavage
1	4/26/2004	348.0	497.2	E	E
2	4/27/2004	260.0	229.5	NE	E
3	4/27/2004	303.0	373.4	E	E
4	4/27/2004	306.0	372.5	E	E
5	6/17/2004	277.0	197.5	NE	E
6	10/25/2004	355.0	676.4	E	E
7	10/25/2004	289.0	347.8	E	E
8	10/25/2004	280.0	295.8	NE	E
9	10/25/2004	294.0	391.6	NE	E
10	10/25/2004	445.0	1500.0	NE	E

Discussion

The use of the gastric lavage technique appears to be consistent with the findings of Light et al. (1983) in that 100% stomach evacuation is achieved with zero mortality incurred. Brosse et al. (2002) found only 67.5% stomach evacuation rates in sturgeon stomachs. Differences of anatomy in sturgeon may account for the lower rate of evacuation (Haley 1998). Hakala and Johnson (2004) noted a 16% mortality and > 90% removal efficiency of gastric lavage in largemouth bass. However, their increased mortality was not significantly different than their control and they held bass in an artificial environment. Our study kept animals in their natural waters, reducing total stress and better simulating an actual field study situation. Hakala and Johnson's (2004) efficiency rating of gastric lavage was based on 30 largemouth bass while this study included only five bass (a total of ten bass were sampled, however, five bass had empty stomachs going into the study). We do not know the percentage of empty stomachs, starting out, of the 30 fish in Hakala and Johnson (2004).

There are some limitations to our study. Lower water temperatures due to sampling at cooler seasons of the year may have kept mortality down. A higher number of sampled individuals over a larger breadth of water temperatures is needed to fully ascertain the effects of this technique on mortality. While our procedure showed a 100% effective rate of gastric evacuation on largemouth bass, our sample size was low. A greater number of fish over all length ranges should be sacrificed to fully know if this procedure is truly 100% effective. A larger sample size may show a slight decrease in evacuation effectiveness as seen in Hakala and Johnson (2004). Effectiveness at different size ranges also needs to be explored.

Conclusion

While a more in depth study is needed to fully explore all facets of this procedure, our data strengthens the use of this technique in largemouth bass. We recommend the use of the gastric lavage technique for use in studies of largemouth bass food habits analyses as an effective, efficient, non-lethal sampling method for stomach contents.

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We would like to thank all the technicians, graduate students, and volunteers who made this project possible. Also, we would like to thank the city of Ames for all their cooperation along the length of this project.

Literature Cited

Brosse, L., P. Dumont, M. Lepage, and E. Rochard. 2002. Evaluation of a gastric lavage method for sturgeons. North American Journal of Fisheries Management 22:955-960.

Cochran, P.A. and I.R. Adelman. 1982. Seasonal aspects of daily ration and diet of largemouth bass, *Micropterus salmoides*, with an evaluation of gastric evacuation rates. Environmental Biology of Fishes 7:265-275.

Light, R.W., P.H. Adler, and D.E. Arnold. 1983. Evaluation of Gastric Lavage for Stomach Analyses. North American Journal of Fisheries Management. 3:81-85.

Hakala, J.P. and F.D. Johnson. 2004. Evaluation of a gastric lavage method for use on largemouth bass. North American Journal of Fisheries Management 24:1398-1403.

Haley, N. 1998. A gastric lavage technique for characterizing diets of sturgeons. North American Journal of Fisheries Management 18:978-981.

Hayward, R.S. and M.E. Bushman. 1994. Gastric evacuation rates for juvenile largemouth bass. Transactions of the American Fisheries Society 123:88-93.

Pope, K.L., M.L. Brown, W.G. Duffy, and P.H. Michaletz. 2001. A caloric-based evaluation of diet indices for largemouth bass. Environmental Biology of Fishes 61:329-339.

Seaburg, K.G. 1957. A stomach sampler for live fish. The Progressive Fish Culturist 19:137-139.

CHAPTER 5. GENERAL CONCLUSIONS

Summary

The management decisions needed for Ada Hayden Heritage Park (AHHP) are complex due to two confounding goals. First, the Ames staff desire a high quality reserve water source. Second, other staff desire a quality fishery to further promote the value of its parks and recreational facilities. Both goals are not completely exclusive of each other, but they do create a broad range of complex management issues for the parties involved.

AHHP can be characterized as a gravel quarry pit with limited littoral zone, low fertility, limited habitat, low sport fish production, and overly high species diversity with the presence of gizzard shad. The crappie population at AHHP is robust, but may have limited recruitment. Bluegills are generally unbalanced with smaller than normal fish present while largemouth bass in AHHP are robust and well balanced. High water quality usually yields high quality fish; however, it does limit overall productivity. A high quality fishery may not be available at AHHP due to these factors.

The fishery's condition before and after new exploitation is relatively unchanged except that angler introduction of new species has most likely occurred. Electro-fishing surveys did not find any major significant differences in CPUE, PSD values, or relative weights related to exploitation. Largemouth bass did utilize more gizzard shad and dipterans after exploitation began; however, it is unknown if this is related to exploitation or just a natural temporal variation.

Angler exploitation has dropped off significantly. This may be due to city regulations. There is evidence that reduced bag limits have no effect on some species (Don Bonneau, Iowa Department of Natural Resources, personal communication) as the majority of anglers do not catch enough fish to be affected by bag limit regulations. However, rapidly decreasing angler exploitation rates may not be caused by direct effects from the city's fishing regulations. Rather, it may be the indirect effects.

Smaller bag limits on this body of water surrounded by other recreational areas with less stringent bag limits may keep anglers away or from initially driving long distances to get to this new fishery. Anglers were not drawn from a large area; ninety percent of anglers were within a 40 km radius of Ames. Thus, the health of the AHHP may not be in decline because of anglers harvesting fewer fish due to regulations but fewer anglers desiring to use this park, due to the regulations.

We estimated that anglers exploited 13% of the available bluegill ≥ 100 mm. Crappie was the most targeted species by anglers accounting to roughly 80% of the total fish biomass harvested during July through October. An exploitation rate on crappie could not be completed due to lack of recaptures and a consequent population estimate. However, the low exploitation of bluegills, low overall angler use rates, and no documented changes in crappie species by electro-fishing surveys, lead us to believe the exploitation rate of crappie has not significantly affected the fishery. Angling effort decreased so quickly, species have most likely not been affected. This creel survey has only estimated usage of AHHP over 4 months, not including an ice fishing season.

Ice fishing anglers can rapidly exploit a fishery and have been shown to retain more of the caught fish than open water anglers. The ice fishing season of 2004 to 2005 and future exploitation in general could lead to a general decline in the crappie fishery at AHHP.

However, there were only 4 months of study period after exploitation began. Initially this study was proposed with new exploitation beginning in November 2003; construction delayed the public fishery opening until July 2004. Other studies have looked at changes from exploitation over a 6 to 4-year time period, significant impacts due to exploitation may yet occur in the future with additional fishing pressure at AHHP.

Management recommendations

The AHHP sport fishery is limited by the available energy present. Further increasing littoral habitat with more shallow areas will increase: macrophyte density for better habitat, invertebrate abundance in the littoral zone for better prey items, spawning areas, age-0 fish rearing areas, and angler usage by making more of the fishery available to shore anglers. The addition of woody habitat, such as conifer trees, to relatively shallow areas could dramatically increase rearing and refugia habitat for many species.

Boat anglers were noted as having higher harvest rates than shore anglers during the creel survey. Adding coarse, woody, habitat should increase the shore angler catch rate as well. Angler catch rates and mean trip lengths have decreased from the high opening levels; providing further opportunities for shore anglers will only help the park's image and not hurt the fishery.

Some current regulations may need to be revised. The protection of spawning zones may not be needed with such little bluegill exploitation. Largemouth bass exploitation is basically zero with the present catch and release fishery. Crappie populations may have variable reproduction, but they are not as vulnerable during spawning as bluegill and largemouth bass and would consequently not be impacted as much by fishing in spawning areas. We do not presently perceive a problem with crappie; variable reproduction in crappie species is common. By increasing the spawning habitat, recruitment into sizes preferable by anglers should increase. We recommend not protecting spawning grounds at this time but further utilizing future fishery surveys to assess crappie reproduction and adult survival.

Along with electro-fishing surveys, we also recommend the use of other gear types to assess this fishery. Our study was based mostly upon electro-fishing gear samples. The unique characteristics of a quarry do not allow good recruitment of fish species to this gear type. Future studies could incorporate the use of fyke, vertical and/or horizontal gill, and/or trammel nets; however, even these gear types have their biases, limitations, and/or drawbacks. The use of more gear types may give a more representative sample of the fishery.

Intentionally stocking additional species into AHHP further reduces the presently limited sport fish production. Smallmouth bass were stocked into AHHP where we fully expected to see smallmouth already present. However, no smallmouth bass were sampled except for fish resembling the stocked individuals after stocking.

AHHP does represent good conditions for smallmouth bass because of its high water quality and possible submerged rocky outcroppings. Yet, largemouth bass have been noted to be more effective at capturing prey in lentic situations than smallmouth bass and consequently would out-compete smallmouth bass in lentic environments. At AHHP, this likely competition may have already occurred from past introductions of smallmouth bass from flooding of the Skunk River. It is not cost effective to stock further individuals into such a competitive situation.

However, if further species are intentionally stocked by city of Ames personnel, it is in the best interests to follow proper stocking protocols to maximize survival of stocked individuals. Acclimate fish to receiving water by mixing receiving and hauling water slowly together. The stocking of fish should occur during cooler times of the year, day, and at late evening to reduce immediate mortality. Further, a stocking validation program is recommended for any new species so future fisheries surveys would be able to discern, for example, that the sampled smallmouth in October 2004 were from stocking or natural reproduction.

Future fisheries surveys should be conducted at least once a year to assess the condition of the fishery and to refine or change any pertinent management decisions.

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